

APRIL 5, 1979

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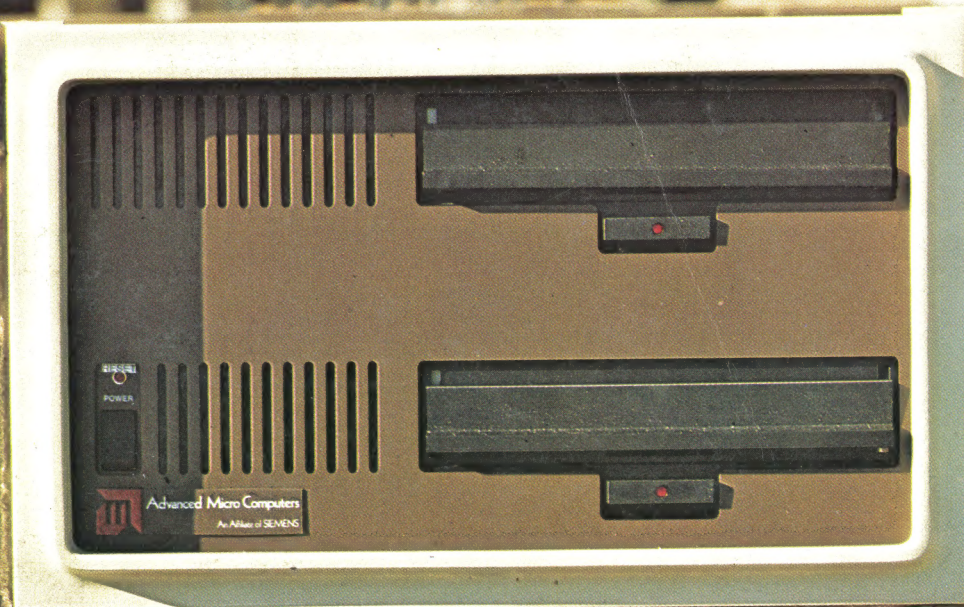
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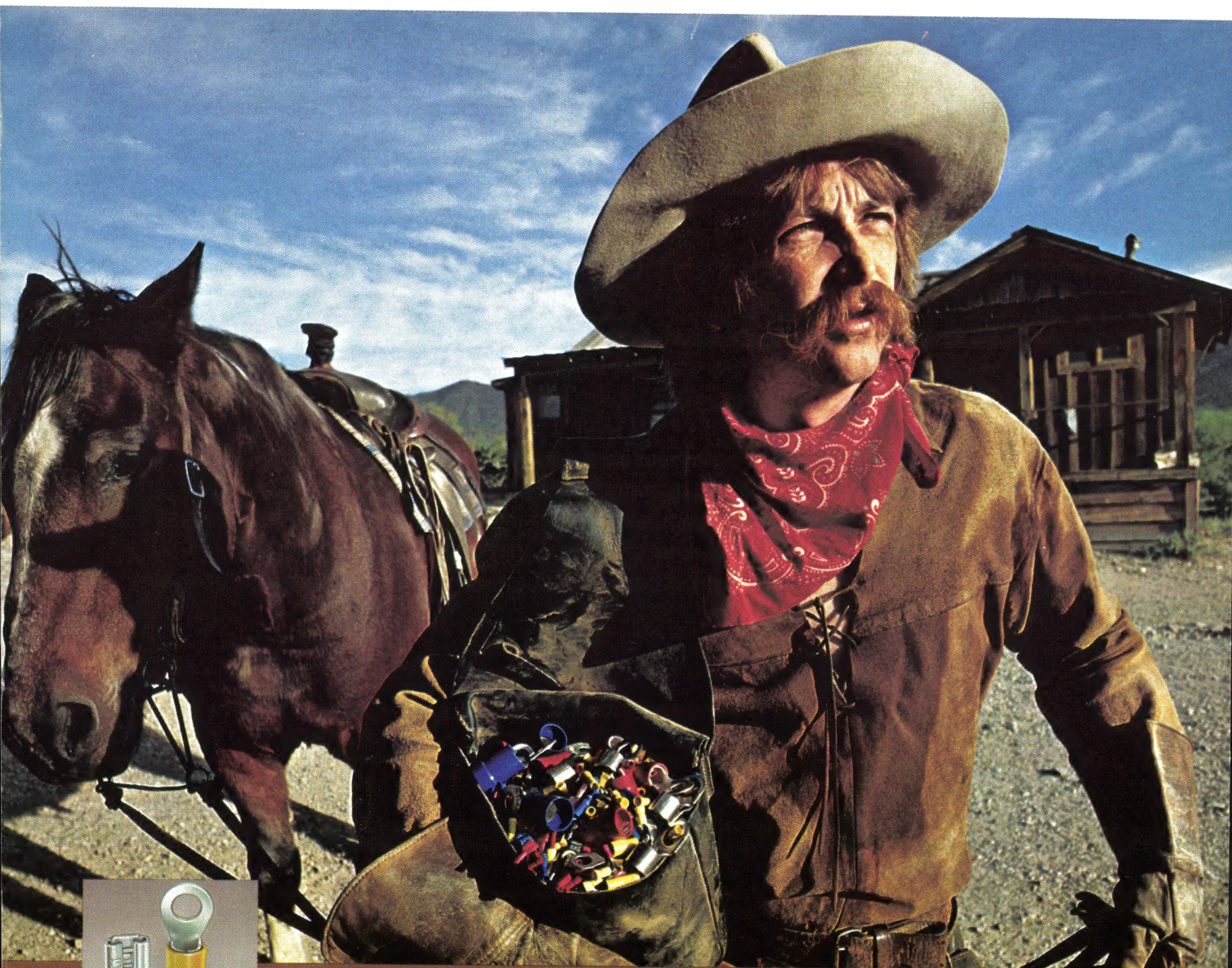
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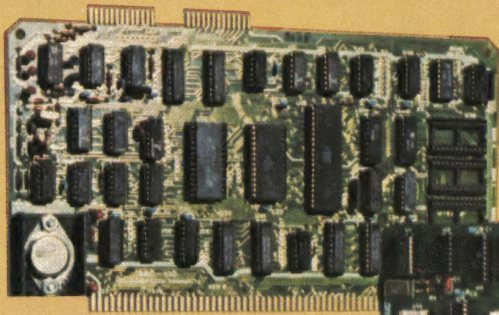
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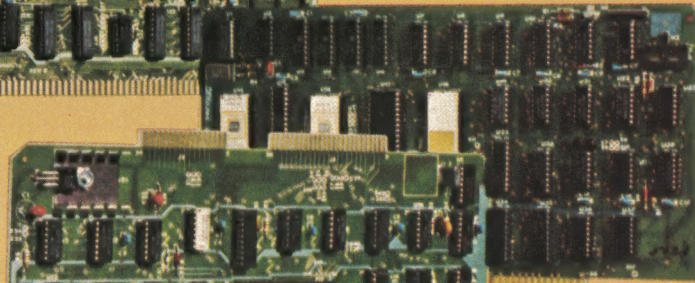
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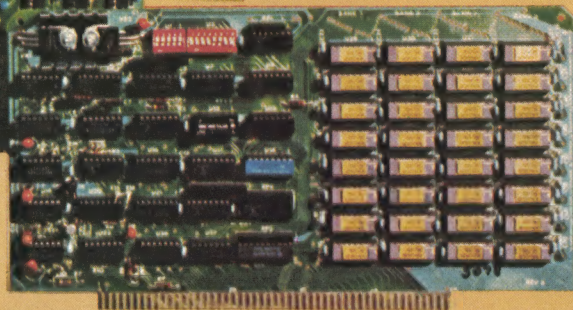


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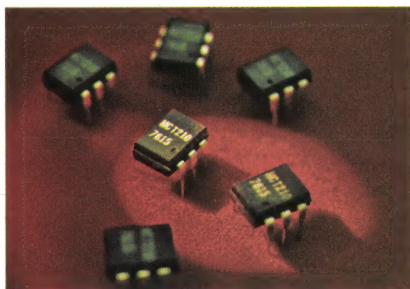
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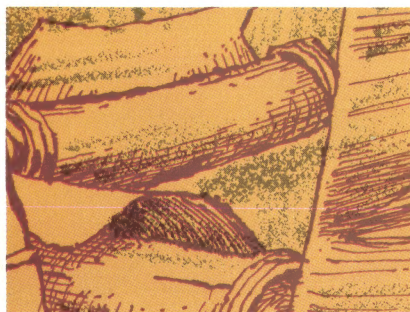
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Optoisolators find use in a variety of new applications (pg 48).



The PASCAL language offers designers a host of opportunities—and some dilemmas (pg 78).



On the cover: A μ C development system is the cornerstone of effective system design (pg 62). (Photo courtesy Advanced Micro Computers)

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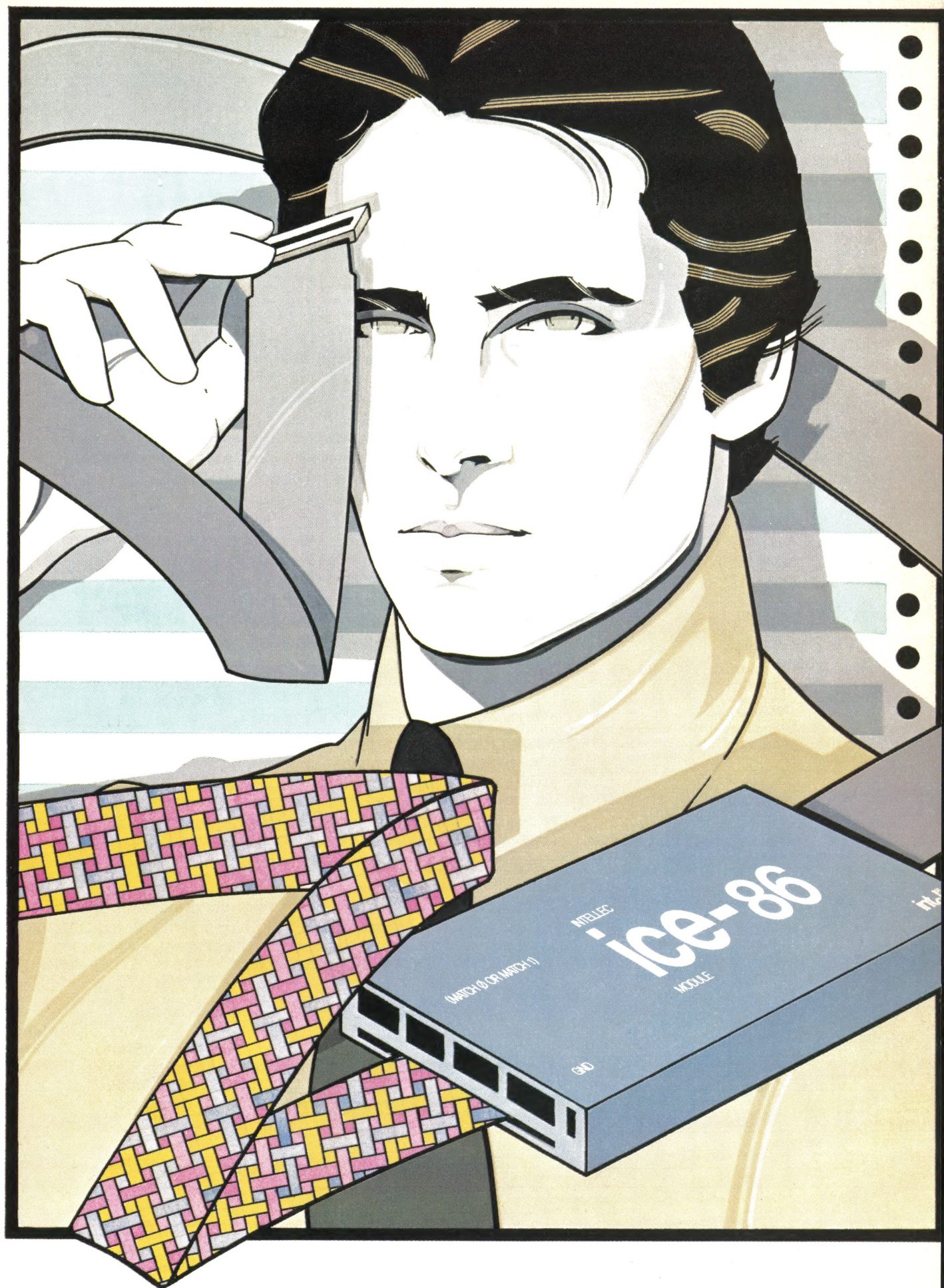
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EDN (USPS 074-090) is published semimonthly (except monthly in July and December) by Cahners Publishing Company, Division of Reed Holdings, Inc. 221 Columbus Avenue, Boston, MA 02116. Norman L. Cahners, Chairman; Saul Goldweitz, President; William M. Platt, Vice President/Division Manager. Controlled Circulation paid at Pontiac, IL 61764 and Oakland, CA 94623. Postmaster: Send Form 3579 to EDN, 270 St Paul St, Denver, CO 80206. Advertising and editorial offices: 221 Columbus Ave, Boston, MA 02116. Phone (617) 536-7780. Subscription offices: 270 St Paul St, Denver, CO 80206. Phone (303) 388-4511. EDN is circulated without charge to those qualified. Subscription to others in the continental US: \$2/copy (special issues may vary), \$25/year; international subscriptions: \$40/year (\$30/year in Canada), with air mail delivery available at additional cost. Send requests for qualification forms and/or change of address to subscription office.

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The ICE-86 cable plugs into your system cpu socket to provide emulation of system operation, up to the full megabyte of memory the 8086 can address.

Communicate in English, or symbolic references.

The ICE-86 emulator is actually a complex breakpoint and logic trace system supporting the most advanced symbolic debugging techniques. English-like statements or symbolic references entered at the Intellec keyboard eliminate the need to search memory maps, keep track of address changes or get bogged down in the details of system operation.

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PL/M-86 for the Architecture of the Future.

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PL/M-86 is an ideal example of the block-structured languages the 8086's futuristic architecture can support. It gives you 32-bit floating point arithmetic and 16-bit signed integer arithmetic. And it takes full advantage of the program-compacting features of the 8086, such as hardware multiply and divide and byte-string operations.

PL/M-86 is best for fast composition of large and complex programs. For those who prefer the efficiency of assembly language, there's ASM-86. And CONV-86 converts 8080/8085 code to the 8086.

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We've compiled an in-depth Success Manual for 8086 Users, detailing the Intellec Microcomputer Development System, ICE-86 and the full software package for 8086 program development. For your copy, contact your local Intel sales office. Or write: Intel Corporation, Literature Dept., 3065 Bowers Avenue, Santa Clara, CA 95051.

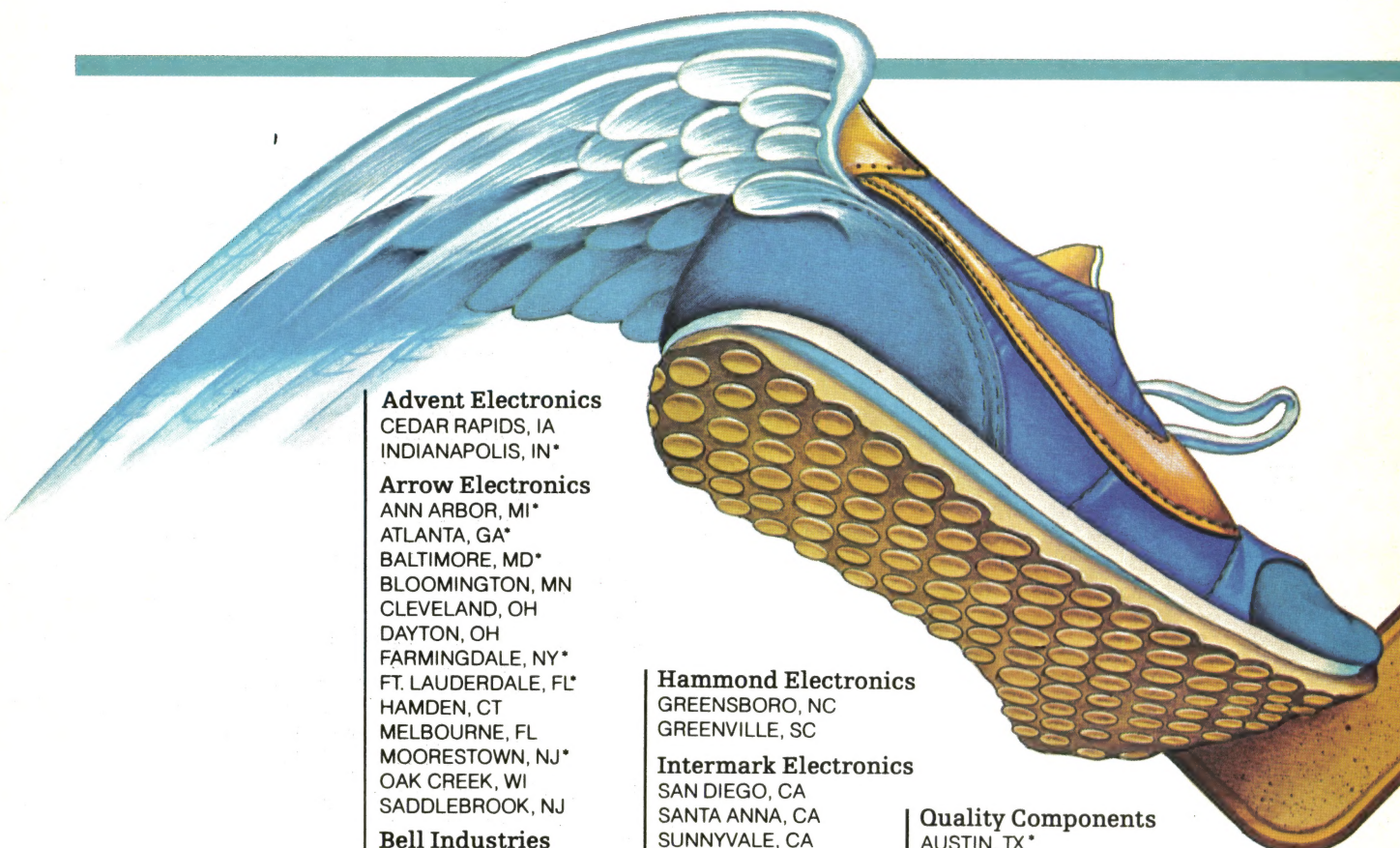


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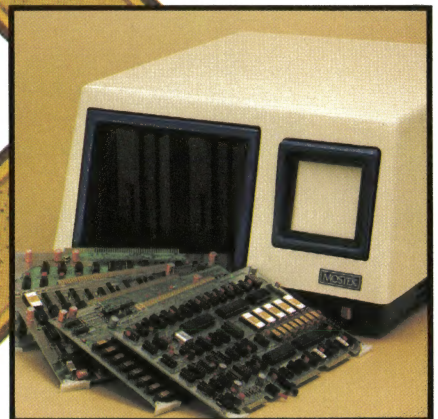
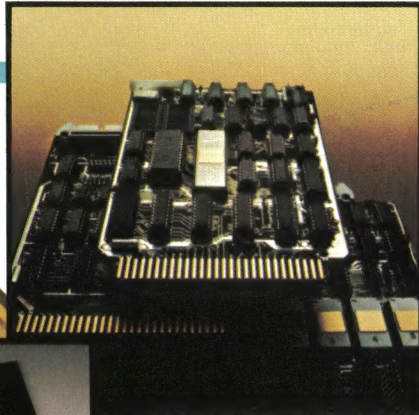
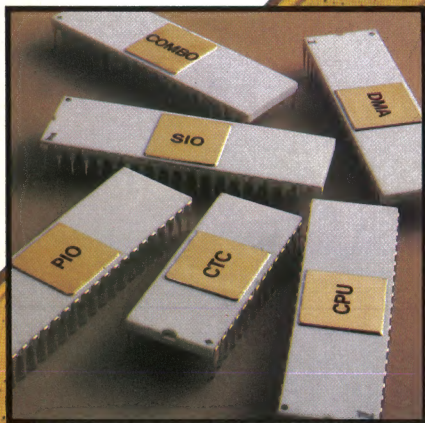
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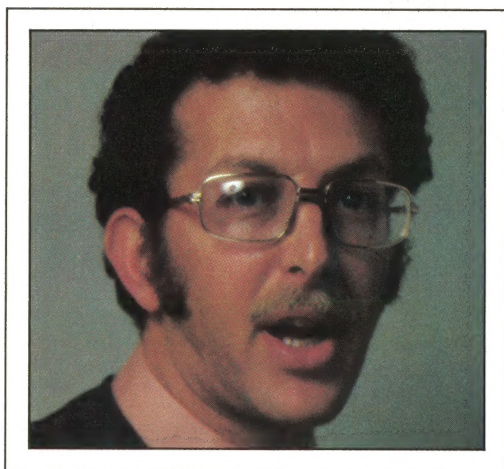
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through thick manuals looking for escape clauses, the Starplex System guides you through your work path with a series of menus, prompts, lights, and audible signals.

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do not hesitate to publish here a comparison chart which will show at a glance where things really stand.

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dard ASCII keyboard in addition to the special function keypads.

We would jump at the chance to tell you the whole story in detail. Write or call me for a complete brochure on the Starplex Development System. Address your request to Mark Levi, General Manager, Microcomputer Systems, National Semiconductor Corporation, Drawer 31, 2900 Semiconductor Drive, Santa Clara, California 95051. Or dial these toll-free numbers: 800-538-1866; 800-672-1811 in California.

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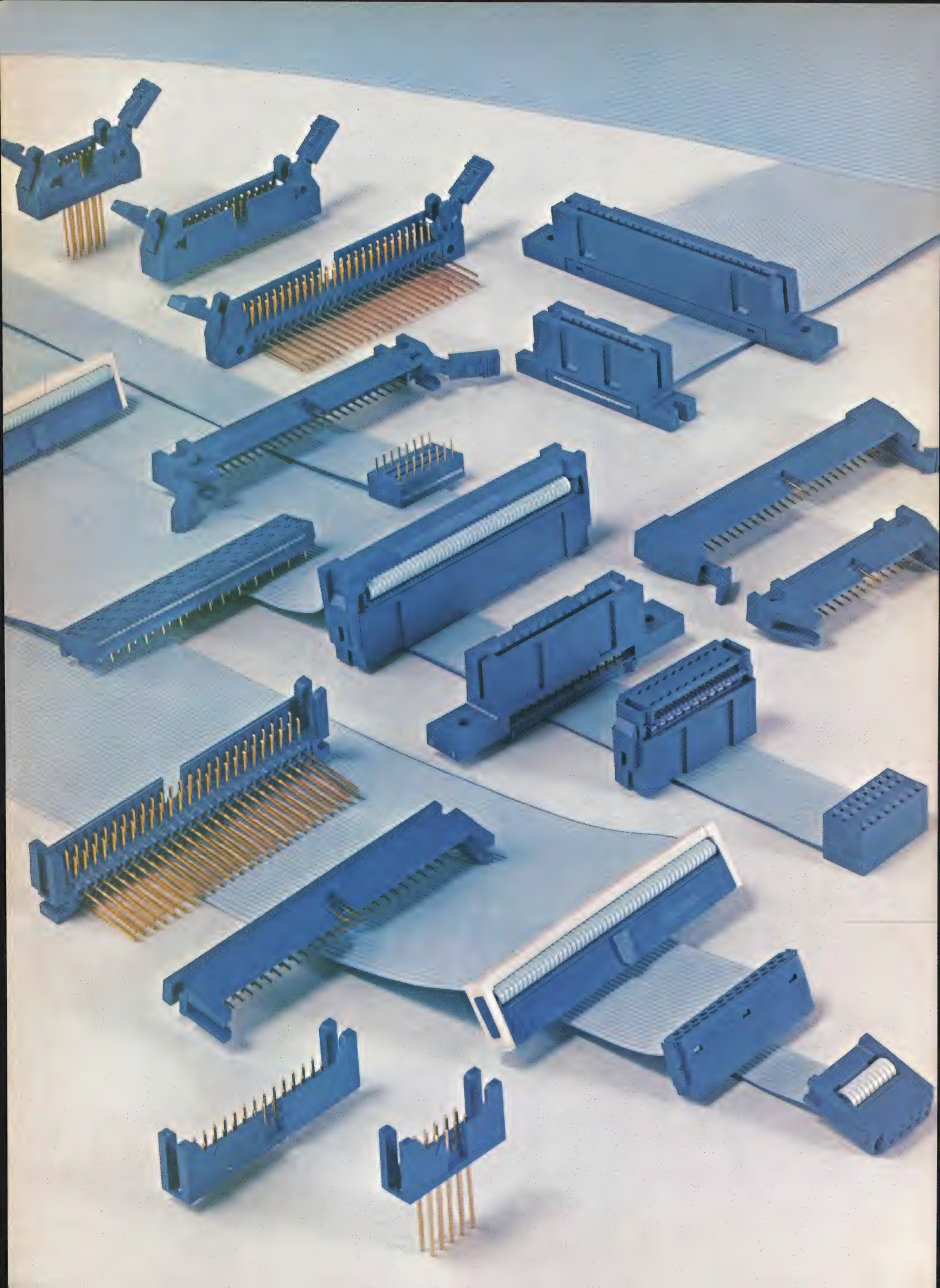
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	Product	Bw	Dual Trace	Delayed Sweep	Fastest Sweep Rate	Other Special Features	Price*
Storage Models	466	100 MHz @ 5 mV/div	yes	yes	5 ns/div	3000 div/ μ s stored writing speed	\$5355
	464	100 MHz @ 5 mV/div	yes	yes	5 ns/div	110 div/ μ s stored writing speed	4375
	434	25 MHz @ 10 mV/div	yes		20 ns/div	Split-screen storage	3480
	314	10 MHz @ 1 mV/div	yes		100 ns/div	Only 10.5 lbs (4.8 kg)	2645
	214	500 kHz @ 10 mV/div	yes		1 μ s/div	Only 3.5 lbs (1.6 kg)	1595
	T912	10 MHz @ 2 mV/div	yes		50 ns/div	Low-cost bistable storage	1545
Nonstorage Models	485	350 MHz @ 5 mV/div	yes	yes	1 ns/div	Widest bw in a portable	5725
	475A	250 MHz @ 5 mV/div	yes	yes	1 ns/div	High-performance 250-MHz portable	3800
	475	200 MHz @ 2 mV/div	yes	yes	1 ns/div	Highest gain-bw in a portable	3435
	465	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 100-MHz bw	2495
	465M	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Triservice standard 100-MHz scope	2620
	455	50 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 50-MHz bw	2055
	335	35 MHz @ 10 mV/div	yes	yes	20 ns/div	Only 10.5 lbs (4.8 kg)	2175
	305	5 MHz @ 5 mV/div	yes		0.1 μ s/div	Autorangeing DMM	1725
	221	5 MHz @ 5 mV/div			100 ns/div	Only 3.5 lbs (1.6 kg)	1190
	213	1 MHz @ 20 mV/div			400 ns/div	DMM/Oscilloscope @ 3.7 lbs (1.7 kg)	1595
	212	500 kHz @ 10 mV/div	yes		1 μ s/div	Low cost for dual trace & battery	1190
	T935A	35 MHz @ 2 mV/div	yes	yes	10 ns/div	Delayed sweep and differential	1535
	T932A	35 MHz @ 2 mV/div	yes		10 ns/div	Variable trigger-holdoff and differential	1245
	T922	15 MHz @ 2mV/div	yes		20 ns/div	Low-cost dual-trace scope	975
	T922R	15 MHz @ 2mV/div	yes		20 ns/div	Rackmount version of T922	1345
	T921	15 MHz @ 2mV/div			20 ns/div	Lowest-cost TEKTRONIX Portable	795
Time Interval Readout	DM44	Optional, factory-installed, direct numerical readout of time intervals and DMM functions for the 464, 465, 466, 475 and 475A					445

*U.S. sales prices are F.O.B. Beaverton, OR. For price and availability outside the United States, please contact the nearest Tektronix Field Office, Distributor or Representative. Prices are subject to change without notice.



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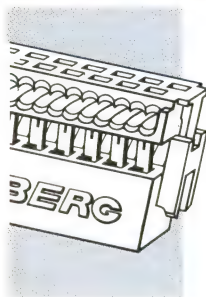
Quickie™: the total IDC System for design flexibility, fast assembly, reliable connections.

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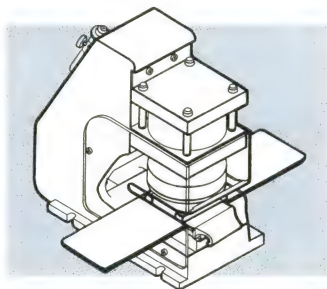
Efficient assembly saves time, material and money.

All connectors in the Quickie* system deliver reliable terminations in just a few seconds because:



- Cable slot designed to precisely position conductor for reliable termination, higher yields.
- Sight holes in cover permit visual inspection before and after assembly assuring proper cable alignment.

• The semi-automatic applicator completes terminations with a slide motion reducing assembly time. Or choose the manual applicator designed to minimize operator fatigue.

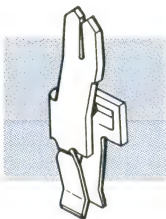


Over seven years proven performance. You can rely on "Quickie".

"Quickie" connectors are now specified by many of America's most quality conscious

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2. Dual-beam contact assures redundant positive pin connection, even when subjected to vibration.

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*Du Pont's trademark for its mass termination connectors, cable, presses and accessories.

"Use my program to enhance your design of networks and filters"

Vic Bennett

"I just couldn't stand the tedious parameter conversion and data re-entry needed to do good network design, but I don't like to use cut & try methods either. So... I tried to find a CAD program to do the job for me.

I wasn't able to find one sophisticated enough to do the job I wanted for less than \$10,000... so I decided to write my own instead.

I'm glad I did because it's quick and easy to use and gives me the exact information I want in the form I want to see it. In fact, it not only solves the problems of RF network design, but can also be used to enhance the design of low frequency networks. By using the program, I have found that I can greatly increase the bandwidth of a low frequency network without having to use costly components.

It occurred to me that lots of engineers may be in the same boat I was -- facing a very sophisticated design task with a very unsophisticated budget. To help you out (and to pay for all the time I spent writing the program), I am offering the use of the program to everyone... at a price anyone can afford.

To give you an idea of how you use the program, there are three modes of operation:

INTERACTIVE MODE

1. ENTER network configuration in plain English (6 network registers of up to 20 components each plus 4 registers of up to 10 sets each of S-parameter measurements).
2. INTERROGATE system to obtain -- for any frequency -- the following:
 - 2-port parameter matrix representation of the network in any parameter set (H,Y,Z,G,S,T)
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Signals & Noise

Add this to your list

Dear Editor:

Your article on chips and filters for Touch Tone receivers (EDN, January 5, pgs 115-120) was very timely and well prepared. Unfortunately, the article omitted a major manufacturer.

Teltone Corp has manufactured Touch Tone devices since 1968 and has led in the development of these devices for interfacing with tone-related equipment. Our high-performance tone receivers of central-office quality are used by all major telephone companies throughout North America, in various applications internationally and by many equipment manufacturers.

Sincerely,

Earl L Mason

Vice President, Marketing
Teltone Corp
Kirkland, WA

Fine-tuning a keyboard

Dear Editor:

The EDN January 20 Special Report on keyboards (pgs 64-72) seems to ignore a difference in format which has been a problem for us.

The box on pg 65 presenting keyboard specifications for your hypothetical word-processing terminal mentions that the "operator is experienced with high-speed typing on an IBM Selectric." But every keyboard pictured in the article has a Teletype Model 33 format, which differs from the Selectric format in its placement of punctuation and other symbols such as *, +, ", etc. (It's interesting, though, that Teletype Corp's Model 45

uses the Selectric format, as do Digital Equipment's Decwriter and video terminals.)

If an operator had to switch often between an IBM Selectric and any of the keyboards shown in the article, I would expect an error rate substantially higher than if the operator only had to use either one of the two formats. Our experience has shown this to be the case, and we are now standardizing on the Selectric format, mostly because we use those typewriters and a DEC computer.

Very truly yours,

Howard Hamer

Chief Engineer

Dranetz Engineering Labs
South Plainfield, NJ

Misplaced decimal

Mr Sidney Chertok, Director of Information Services at Sprague Electric, has informed us of an error appearing in Table 1 (pg 124) of the January 5 EDN article, "Optimize ripple/EMI performance in switching-regulator designs." The Sprague and Mallory stacked-foil capacitors described there show a typical ESL (nH) of 15—the figures should read 1.5 nH.

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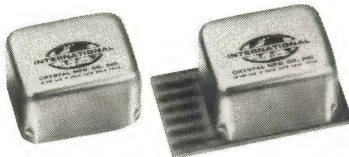
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OE CRYSTAL OSCILLATOR ELEMENTS

International's OE Series of Crystal Oscillator Elements provide a complete crystal controlled signal source. The OE units cover the range 2000 KHz to 160 MHz. The standard OE unit is designed to mount direct on a printed circuit board. Also available is printed circuit board plug-in type.

The various OE units are divided into groups by frequency and by temperature stability. Models OE-20 and OE-30 are temperature compensated units. The listed "Overall Accuracy" includes room temperature or 25°C tolerance and may be considered a maximum value rather than nominal.



input supply less than 12 vdc.

Prices listed include oscillator and crystal. For the plug-in type add the suffix "P" after the OE number; eg OE-1P.

OE-1, 5 and 10 can be supplied to operate at 5 vdc with reduced rf output. Specify 5 vdc. when ordering.

Output — 10 dbm min. All oscillators over 66 MHz do not have frequency adjust trimmers.

All OE units are designed for 9.5 to 15 volts dc operation. The OE-20 and OE-30 require a regulated source to maintain the listed tolerance with

Catalog	Oscillator Element Type	2000 KHz to 66 MHz	67 MHz to 139 MHz	140 MHz to 160 MHz	Overall Accuracy	25°C Tolerance
035213 035214 035215	OE-1 OE-1 OE-1	\$14.24	\$16.35	\$20.57	±.01% -30° to +60°C	±.005%
035216 035217 035218	OE-5 OE-5 OE-5	\$17.67	\$20.83	\$27.43	±.002% -10° to +60°C	±.0005% 2 - 66MHz ±.001% 67 to 139 MHz ±.0025% 140 to 160 MHz
Catalog Number	Oscillator Element Type	4000 KHz to 20000 KHz			Overall Accuracy	25°C Tolerance
035219	OE-10	\$20.83			±.0005% -10° to +60°C	Zero trimmer
035220	OE-20	\$30.59			±.0005% -30° to +60°C	Zero trimmer
035221	OE-30	\$63.30			±.0002% -30° to +60°C	Zero trimmer



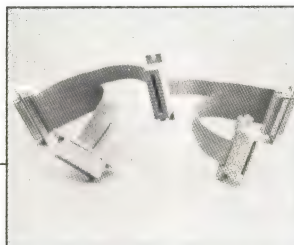
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P.O. BOX 188 • 306 McDONOUGH ST. • ST. CHARLES, MO. 63301

For more information, Circle No 12

Books

Cut confusion with pocket-sized reference

Microprocessor Lexicon. 110 pgs; \$2.95; Sybex Inc, Berkeley, CA, 1978.

One definition of a lexicon is "the vocabulary of a language." Appropriately, this little book doesn't confine itself to the jargon of microprocessorists, but extends into the glut of acronyms that characterizes communications as well.

The bulk of this pocket-sized work attacks the vagaries of terminology. Although far from exhaustive, the definitions are accurate and sufficient for quick lookup.

Numbers play an important part in the dialogues of the digital world. Thus, one section is devoted to "The Numbers Game," wherein the book translates common numeric designations.

The lexicon also mysteriously includes two manufacturers lists: one for μ Ps, another for μ Cs. Perhaps such lists serve a purpose, yet the industry's quicksilver nature renders the completeness and accuracy of any list in book format doubtful.

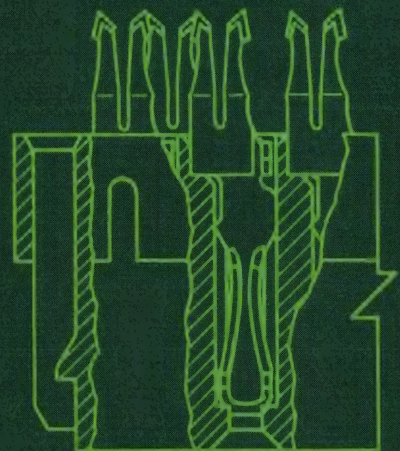
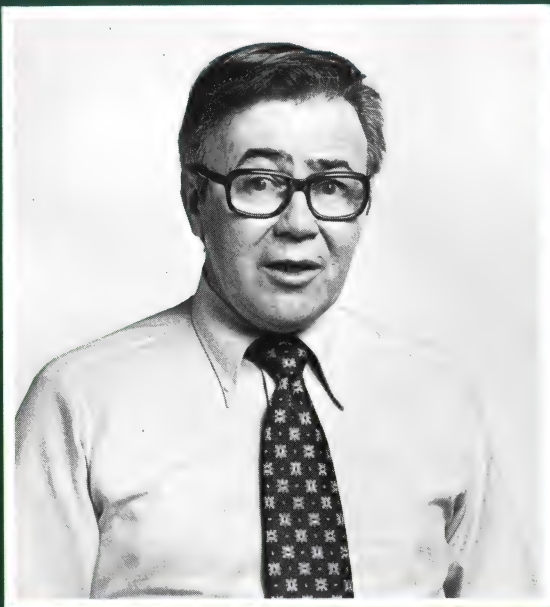
Realistically, if you're in the business, you probably don't need this book. Giving it to an engineering manager (or a nontechnical friend, for that matter), though, could save time and effort for both of you.—**Ed Teja**

JOB SHOPPING?

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EDN: Everything Designers Need

“Look, I’ve got two challenges for my ribbon cable interconnects — to reduce manufacturing rejection rates and prevent contact damage during testing. Got any solutions?”



AMP Latch.



Some facts worth knowing about AMP Latch Connectors

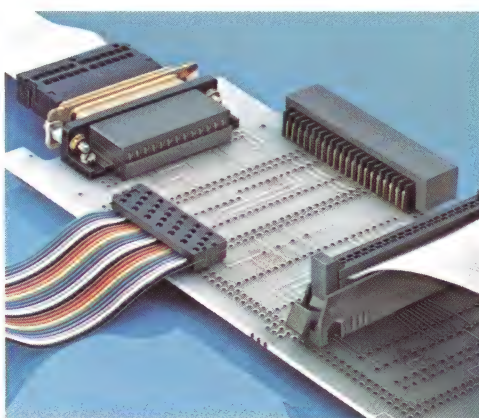
Function: Simultaneous mass termination of all conductors without cable stripping.

Wire types: Small gauge solid or stranded discrete wires as well as flat ribbon, woven ribbon and other types flat cable with round conductors on .050" centers.

No. of positions: 10 to 60.

Connector types: Wide variety of cable-to-cable, card edge, DIP and receptacle connectors available.

Mates with: Full range of AMPMODU headers and pcb posts.



Electrical Current Rating:

1 Ampere (Continuous).

Operating Temperature Range:

-55°C to +105°C.

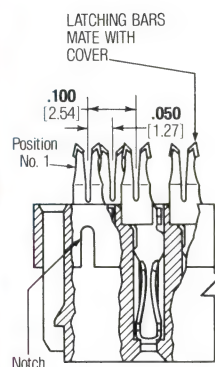
Dielectric Withstanding Voltage:

500 Volts, RMS.

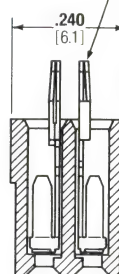
Tooling available: Pneumatic and Manual Bench Mounted Models and a Hand Tool, each with interchangeable die sets.

Who to contact: Call AMP Latch Information Desk at (717) 564-0100. Ext. 8400. Or write AMP Incorporated, Harrisburg, PA 17105.

Product Information: Check Reader Service Number 99.



FOLDED DESIGN FOR FOUR POINTS OF TERMINATION



As fast as you can say "downtime" your production, test or repair people can activate an AMP Latch Easy Release Header with one hand. Just squeeze and the cable half is disengaged. No wrenching on the cable. No wiggling. And no damaged contacts. An important matter when

We sure do.

neither your production costs nor your on-board costs can take a back seat to one another. And one of many reasons why AMP Latch has drawn the attention of designers in the data processing, instrument and communications industries.

Yet AMP Latch offers a unique feature that extends far beyond what other ribbon cable connectors can offer. It offers precision registration built into the tooling which minimizes rejection rates.

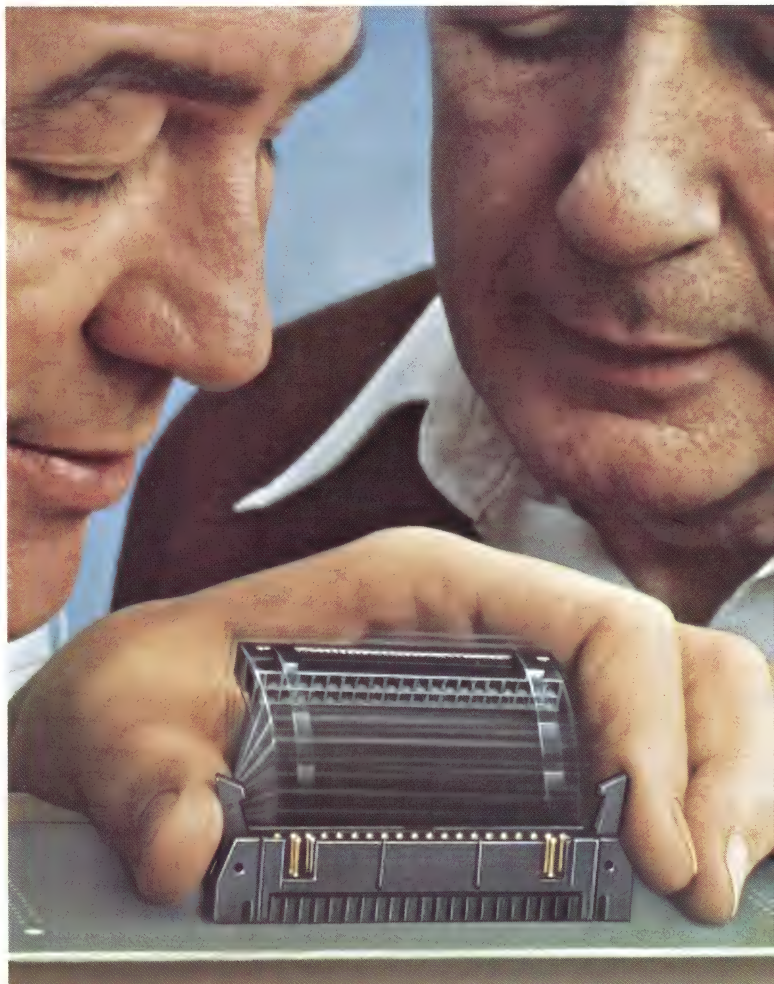
Unquestioned reliability. That's what AMP Latch is about, too. You get a four-point electrical contact and mechanical grip for each conductor.

Built-in inspection ports make test simpler than ever.

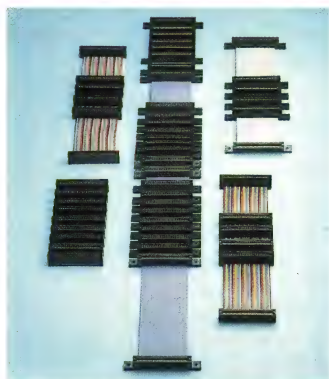
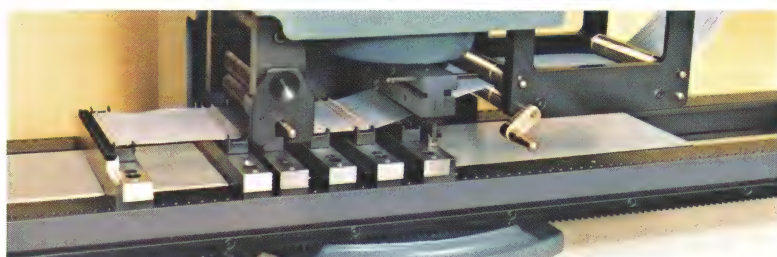
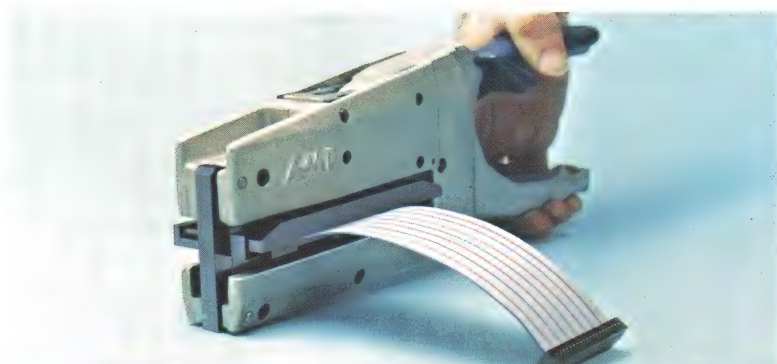
The fact is, nobody today has a wider range of easy-to-apply no-strip, no-solder, round conductor flat cable connectors than AMP.

For more details, see the opposite page and the page overleaf.

AMP has a better way.



And cost effective tooling.



With AMP Latch Tooling the terminations are made quickly, easily and simultaneously. No need for pre-stripping the insulation. One tool will terminate virtually all popular round conductor flexible cable, including those with flat side down or ribbed side down.

Two basic bench-mounted AMP Latch tools include: a heavy-duty pneumatically powered unit and a manually operated unit. Both are reliable. Both are easy to load. And precision cable registration is built in. Alignment is automatic and positive. Six different precision die sets are available for terminating receptacle, plug, card edge, paddle board and pin connectors as well as discrete wire.

Also available is equipment for daisy chain terminations, and a hand tool with interchangeable dies.

For the complete story on AMP Latch Connectors, AMP Latch Tooling, and the AMP Technical Support that goes with them, call AMP Latch Information Desk at (717) 564-0100. Ext. 8400. Or write AMP Incorporated, Harrisburg, PA 17105.

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The last time you saw a really new bench/portable DMM was 1972.

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Now, look at the new 8010A and 8012A: single-chip CMOS designs for problem-solving in the eighties!

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TOUCH AND HOLD probe option, so you can thread your way through a component jungle and capture the reading you need.

FUNCTIONPOWER: 22 ranges of AC and DC volts and current, six ranges of resistance, and three ranges of conductance — the missing function on other bench multimeters.

CONDUCTANCE RANGES for noise-free leakage measurements to 10,000 M Ω . A valuable function for bench-testing boards and components, conductance also measures transistor beta (using a bias resistor) and light intensity (by using a photocell).

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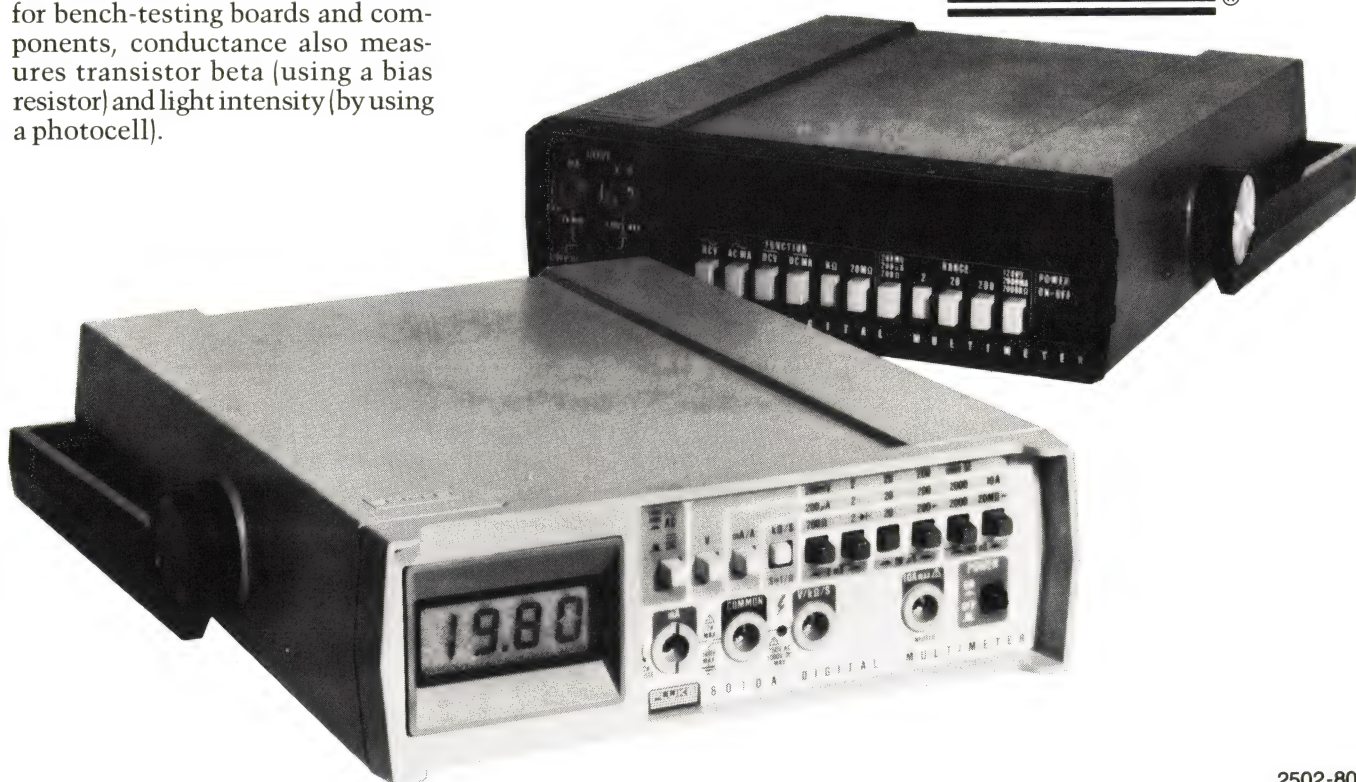
LEADERSHIP HAS TO BE EARNED. And we're committed to keeping the price of your confidence as realistic as possible. Like \$239 for the 8010A with a 10A current range, and \$299 for the 8012A with two extra-low ohms ranges that allow measurements from 0.001 Ω to 10,000 M Ω — making it the widest range ohmmeter available!

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C3	5.00	5.00	2.00k
C4	15.0	15.0	2.00k
C5			
C6			
C7			
C8			

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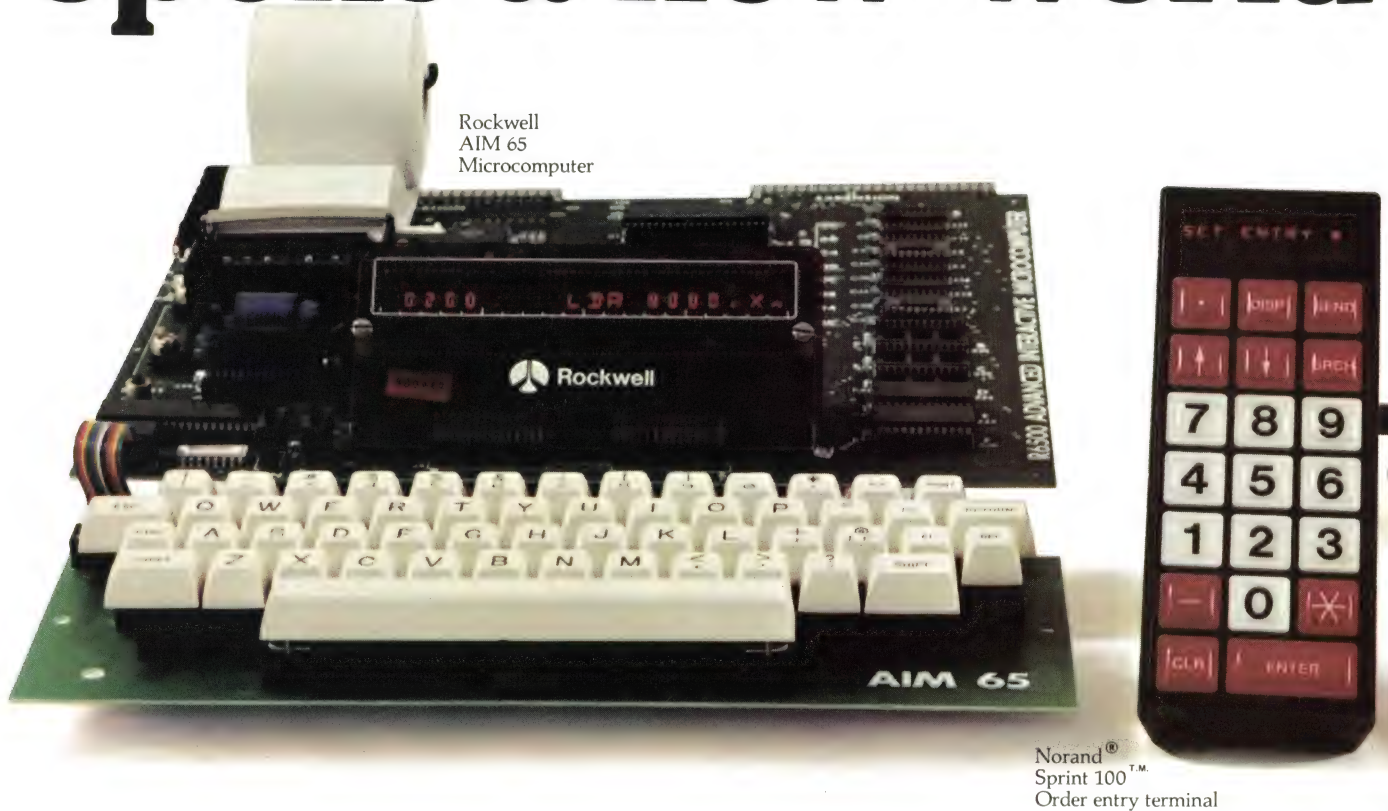


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How Litronix' opens a new world



Now designers have a communications peripheral perfectly matched in size and cost to the world of microcomputers.

Litronix invented the Intelligent Display* to give microcomputers a new way of "talking" to users in words, numbers or even sentences. And not surprisingly, these displays are already

Part Number	Features	Character Height	Horizontal Row Spacing	Vertical Row Spacing	Viewing Angle	Character Positions	Character Segments
DL-1416	Standard General Purpose Display	.160"	.250"	1.200"	±25°	4	16
DL-1414	Compact Display For Hand Held Equipment	.112"	.175"	.800"	±50°	4	16
DL-2416	Premium Display New Rugged Package	.160"	.250"	.800"	±50°	4	17

*Intelligent Display is a trademark of Litronix, Inc.

beginning to create a new class of microcomputer-based products.

The Intelligent Display is an alphanumeric LED readout that incorporates ASCII decoder, multiplexer, memory and LED driver in a built-in CMOS IC. It interfaces simply and directly to any microprocessor bus, much like a RAM. Power is from a single +5V supply, and operating current is low enough for any battery powered device.

Litronix puts intelligent communications in the palm of your hand or anywhere panel space is limited. Three versions of the Intelligent Display are already available to fit a wide variety of applications. The smallest lets you fit 20 characters side by side in a space of only 3.5 inches.

Litronix' Intelligent Displays are already being used in the portable terminal, the low cost microcomputer and electronic translator above. They're also ideally suited for applications like control panel readouts. Handheld computer

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Presenting the 93P. Our new half-inch trimmer with its built-in dial is a turn for the better.

For the first time, you can have a cermet half-inch single-turn, with dial setting capabilities. A variable resistor that's somewhere between trimmer and precision pot, designed to save labor costs with screwdriver position adjustability, and high-resistance capabilities.

Now you can write your manuals, and specify fast setting instructions. Using the 93P means reduced labor. It'll take less time to make that initial setting, less time to check the board. Calibration time is minimized. And the

93P has custom dial setting capabilities, too. Cermet technology has many advantages over wire wound. With 10% tolerance, and 100 ohms to 2 meg

ohms resistance range, it wins hands-down at high resistances. Inductive problems are eliminated. And the 93P is sealed for environmental stability.

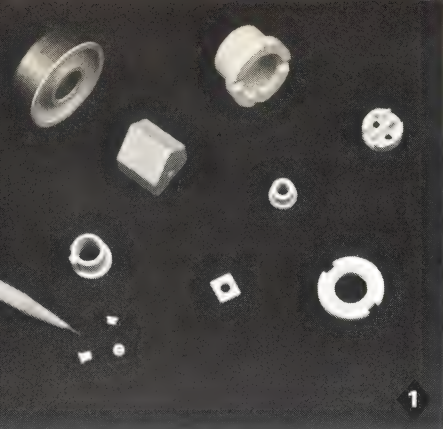
Why a larger cermet part? The longer the element, the more the power dissipation. And it stands to reason, you can get more marking and more adjustability.

Design in a trimmer that's not a trimmer as you've known it until now. The 93P.

Call your local Beckman Helipot distributor for free evaluation samples. To get his number, or immediate technical literature, call (714) 871-4848, ext. 1776. Start designing problems out today.

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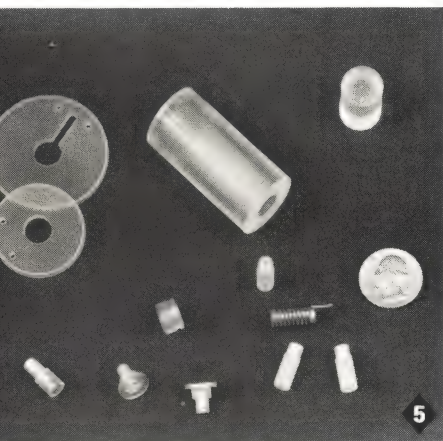
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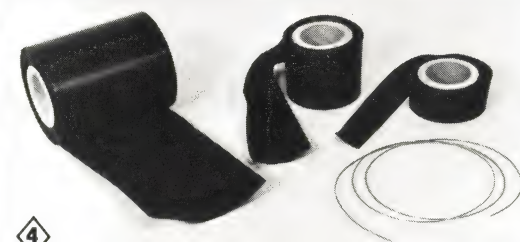
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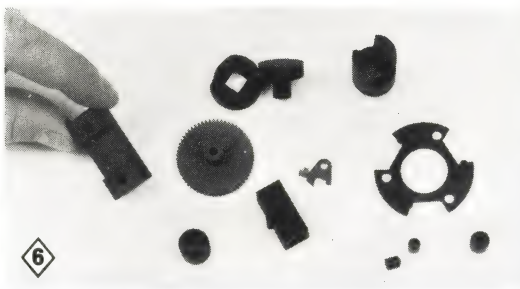
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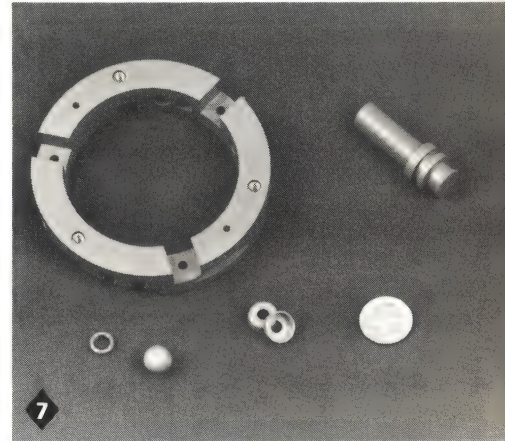
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7

❖ **Fluorosint® 500** — A proprietary synthetic mica-filled TFE with a low coefficient of thermal expansion, Fluorosint 500 offers a wide continuous service temperature range. Form stability remains constant to 650°F and the dielectric constant is only slightly affected by frequency changes. Ideal for coil forms, standoff insulators and electrically insulating wear parts. **Circle no 53**

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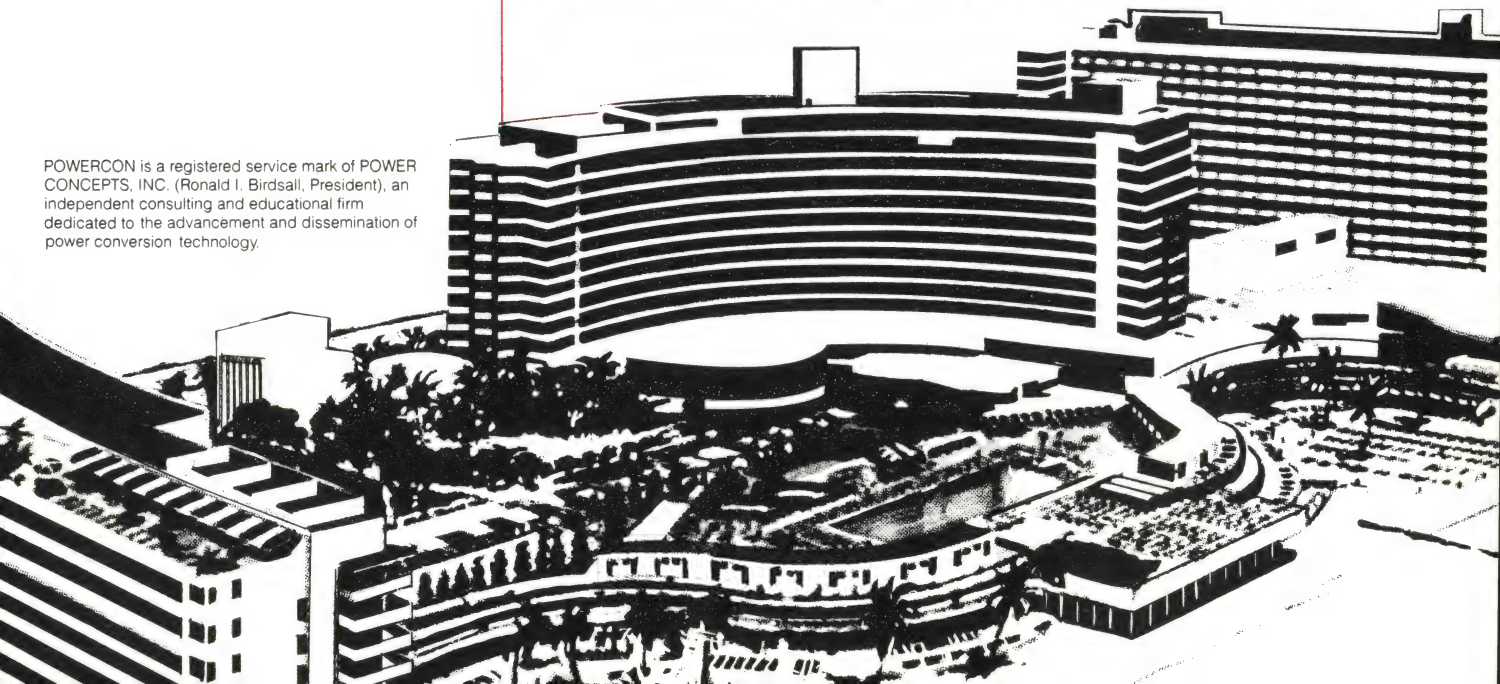
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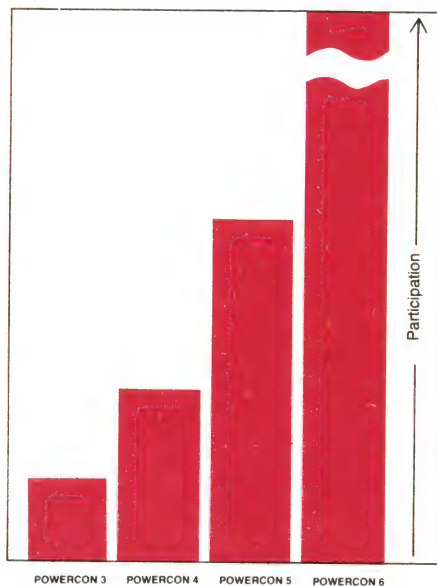
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Leadtime Index

PASSIVE COMPONENTS

PRODUCT	LEADTIME IN WEEKS			PRODUCT	LEADTIME IN WEEKS		
	Min	Max	Trend		Min	Max	Trend
CAPACITORS				Single-sided	7	10	=
Ceramic, disc	6	12	=	RELAYS AND TIMERS			
Ceramic, monolithic	8	14	=	Crystal can	11	15	up
Electrolytic, aluminum	9	15	=	General purpose	6	9	=
Electrolytic, tantalum	8	11	=	Reed, dry	7	11	=
Film	7	12	=	Reed, mercury-wetted	7	10	=
Mica	11	18	up	Solid state	5	7	=
Paper	9	14	up	Telephone	7	13	=
Trimming	7	10	=	Time delay and timer	8	11	=
CRYSTALS, FILTERS AND NETWORKS				RESISTORS, FIXED			
Filter, active	7	10	=	Carbon film	4	6	=
Filter, EMI	14	16	=	Composition	4	8	=
Filter, lumped-constant	10	13	=	Metal film	11	16	up
Filter, quartz (monolithic)	12	16	up	Network	14	22	↔
Frequency determining crystal	10	12	up	Nonlinear	10	14	=
ENCLOSURES				Wirewound	10	14	=
Custom	9	12	=	RESISTORS, VARIABLE			
Modified standard	8	12	up	Pot, nonprecision WW	10	12	=
Standard	6	8	up	Pot, precision WW	14	16	=
FANS AND BLOWERS	20	24	↔	Pot, nonprecision comp	6	8	=
FRACTIONAL HP MOTORS	14	18	=	Pot, precision comp	10	14	=
INTERCONNECTION COMPONENTS				Trimmer, WW	9	12	=
Back panel	4	12	up	Trimmer, comp	7	11	=
Flat cable	4	12	up	SWITCHES AND KEYBOARDS			
Multipin circular high-density	14	19	up	Circuit breaker	9	14	=
Multipin circular standard	12	18	up	Dual in-line	6	8	=
Packaging panel	4	12	up	Keyboard and keyswitch	7	10	=
PC, one-piece	4	12	up	Lighted pushbutton	9	12	=
PC, two-piece	4	12	up	Pushbutton	8	12	=
Rack and panel	4	12	up	Rotary	6	9	=
RF coaxial	11	16	up	Snap action	3	5	=
Socket	4	12	up	Thumbwheel	8	10	=
MAGNETIC COMPONENTS				Toggle	6	9	up
Coil	8	12	up	TRANSDUCERS			
Solenoid	7	12	up	Pressure	6	8	=
Transformer, power	8	12	up	Temperature	5	8	=
Transformer, other	7	12	=	WIRE AND CABLE			
PRINTED CIRCUITS				Coaxial	3	8	=
Double-sided	9	11	up	Flat and ribbon	4	6	up
Flexible	8	10	up	Single conductor hookup	4	8	=
Multilayer	12	14	=	Multiconductor	3	8	=

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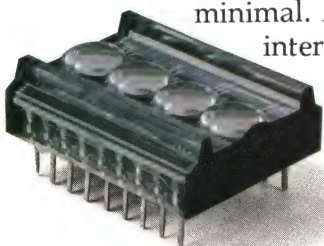
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The VTR's day in court

An important trial is currently underway in the Federal District Court in Los Angeles: the copyright-infringement suit brought by Universal Studios and Walt Disney Productions against Sony Corp. At issue is the use of the Betamax videotape recorder (VTR) to record and replay copyrighted material—in this case, movies produced by the two studios and broadcast on TV. Meanwhile, VTR buyers remain totally

unaware that the outcome of this suit might determine the manner in which they can legally operate their versatile home-entertainment equipment.

Lawyers for the plaintiffs claim that studios, advertisers and creative employees will suffer economic hardships because VTR recordings will significantly reduce the audiences for live TV programming. Replying to this argument, Sony's lawyers challenge the validity of all copyrights related to TV-broadcast material, then cite surveys indicating that most VTR users record programs intact (with commercials) for viewing at a more convenient time, not to build permanent libraries of material.

Against the background of this court trial, MCA (Universal's parent company) and Magnavox have launched a program to market the video-disc player, the VTR's prime competition. A read-only device, the video-disc machine uses special "records"—rugged media containing appropriately copyrighted material. Initial sales of the player are encouraging, thanks to three factors: the availability of considerable "software" (discs containing a wide spectrum of entertainment); the unit's novel operating features, including stop frame; and the rugged nature of the medium. The last factor, incidentally, could encourage the development of a significant swap/sell used-disc market and thus greatly reduce owner costs.

Final disposition of the court case, however, remains some time in the future, because after the judge hands down his ruling (promised within 90 days of final arguments) an appeal to the US Supreme Court is possible. And beyond that, Congress might have to address this public-policy issue.

Yet all this legal maneuvering could be academic. If the VTR/video-disc consumer market develops to a significant size, as it quickly might, and if buyers overwhelmingly choose one video-recording concept over the other, lawyers and lawmakers will be forced to reconfigure the law to accommodate the established reality.

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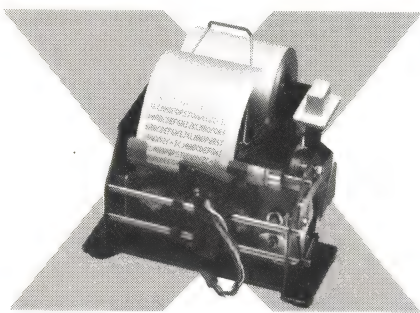
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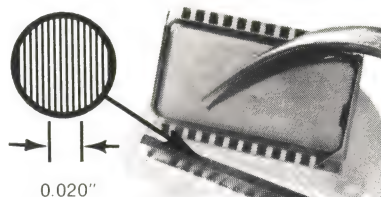
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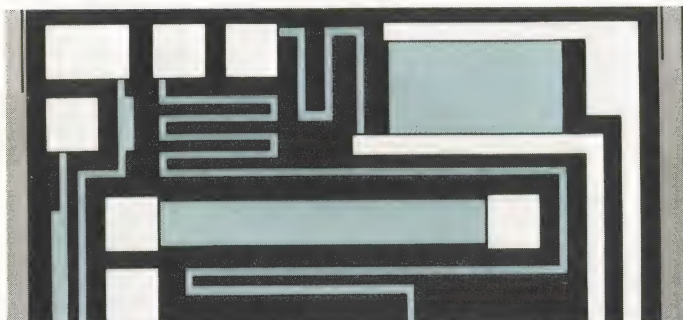
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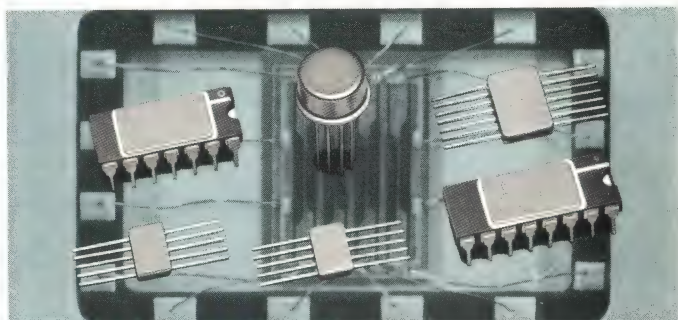
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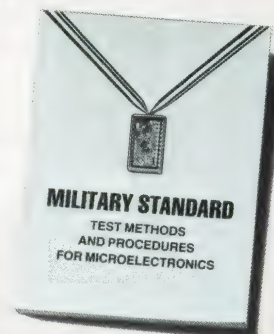
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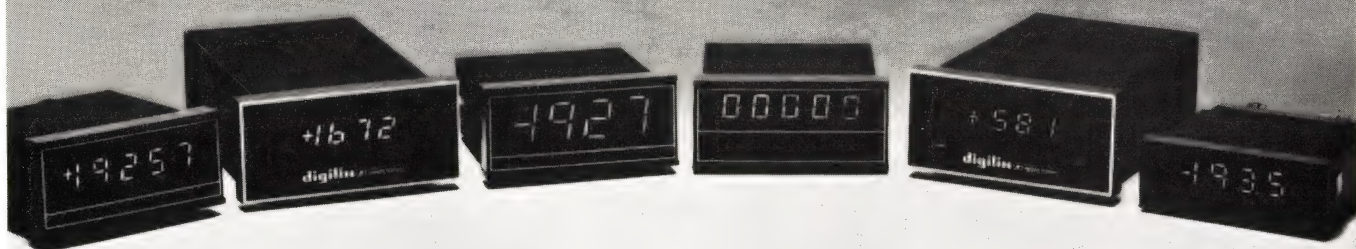
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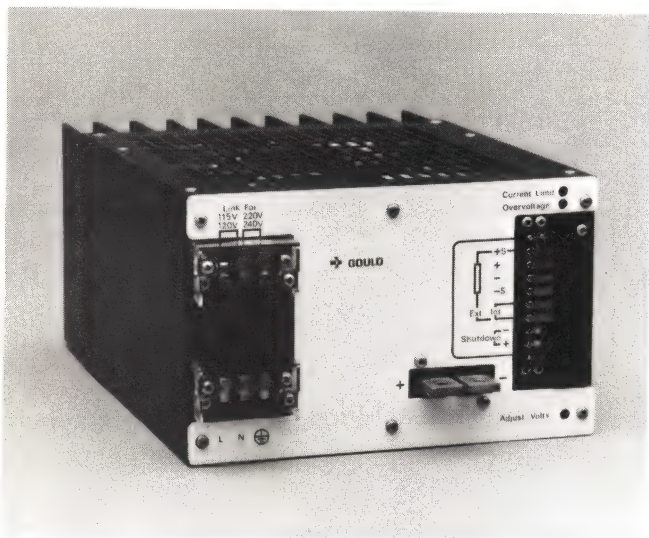
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Technology News

Alternative production technologies promise increased solar-cell use

Dale Zeskind,
Contributing Editor

Solar-cell researchers are investigating a variety of alternative cell technologies, which could lend themselves to less expensive production requirements than current designs. If these researchers succeed in their efforts, photovoltaic energy conversion — once limited primarily to outer-space applications—will quickly be brought to earth in a variety of terrestrial uses.

The US Department of Energy (DOE) is aiding these research efforts. Through its National Photovoltaic Program, the DOE aims to ensure that photovoltaic conversion systems

significantly contribute to the nation's energy supply by the year 2000.

Today, ten US manufacturers produce single-crystal silicon cells and cell

arrays (modules). Unfortunately, these cells require energy- and time-consuming, labor-intensive manufacturing techniques, so their costs are high—on

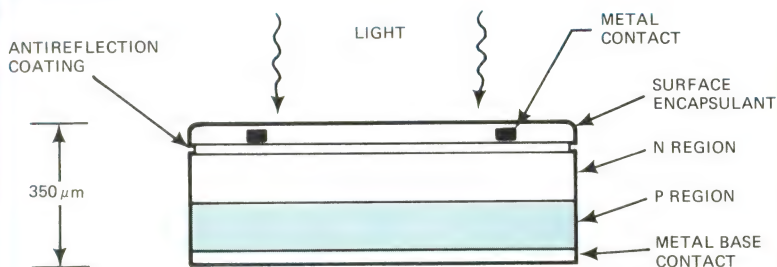


Fig 1—Conventional pn-junction silicon solar cells, made from a wafer of high-quality single-crystal silicon, are commercially available, though expensive. Efficiencies for these cells range between 10 and 15%; the US Dept of Energy hopes that improvements in manufacturing processes and/or the use of alternative cell technologies will eventually make photovoltaic energy conversion cost-competitive with other forms of electric-power generation.

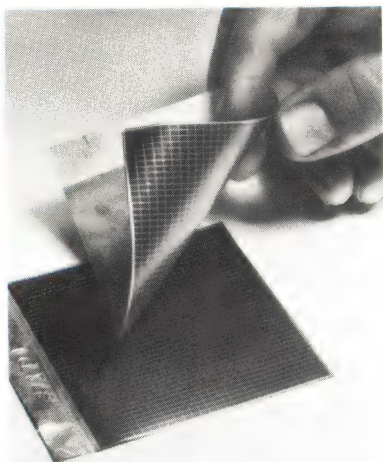
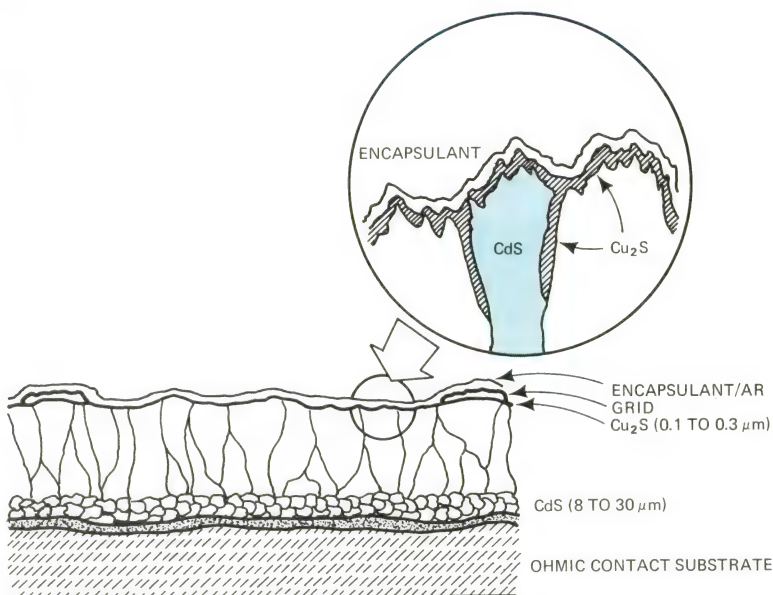


Fig 2—Thin-film solar cells could sell for \$0.25/W (1975 dollars) by 1982. Produced by vapor deposition of CdS onto plastic- or metal-film substrates, these cells readily adapt to continuous-processing techniques. (Courtesy Institute of Energy Conversion)



the order of \$12/W. This high cost limits the terrestrial use of conventional cells to geographically remote applications, such as radio repeaters and navigational aids.

As part of its program, however, the DOE has set a cost goal of \$2/W by 1982 and \$0.50/W by 1986 (in 1975 dollars). At the latter price level, photovoltaic systems should compete for some distributed and larger-load-center utility applications. The resulting increased demand would encourage large-scale cell production and spur a further improvement in availability and cost.

Thin films offer promise

A conventional pn-junction silicon cell (Fig 1) is made from a thick wafer of high-quality single-crystal silicon cut from a slowly grown ingot. (The cutting process turns much of the material to dust—an additional drawback to conventional cell technology.)

After this cutting step, the wafers must be polished, their pn junctions grown by means of high-temperature diffusion, and the necessary contacts plated. These conventional cells have typical solar-to-electric-power conversion efficiencies of 10 to 15%.

To reduce manufacturing costs, one experimental cell-fabrication technique uses single-crystal silicon grown from continuous sheets rather than ingots. Such sheets require less polishing than the conventional ingots, and less material is wasted during cutting.

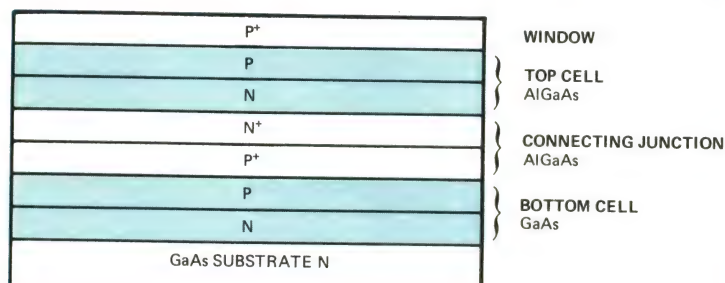


Fig 3—Stacking cells monolithically improves solar-to-electric-power conversion efficiency. But the approach requires optimizing the cells to respond to different portions of the solar spectrum. Each layer is approximately 1 to 2 μ m thick. (Courtesy Research Triangle Institute)

The CdS/Cu₂S thin-film cell pictured in Fig 2, for example, is constructed by vapor-depositing a thin-film CdS layer onto a thin metal substrate or metallized plastic film. Reaction in a solution of CuCl forms the Cu₂S layer.

These cells consume miniscule amounts of materials in their fabrication, and their construction lends itself to continuous (as opposed to batch-type) processing. J D Meakin, director of solar-cell research at the University of Delaware's Institute of Energy Conversion in Wilmington, reports that the CdS/Cu₂S cells are theoretically capable of achieving 16% conversion efficiencies; the practical goal is an 11% figure.

Meakin has to date observed efficiencies as high as 9.15% and hopes to exceed 10% some time this year. His group is currently designing a pilot production plant that he expects will demonstrate the feasibility of producing these or similar cells at a selling price of \$0.25/W by 1982.

Composite methods

Most solar cells respond efficiently only to a limited portion of the solar spectrum, so much of the light that strikes them converts to heat rather than electricity. To solve this problem, researchers have built cells that respond to different portions of the spectrum. Then, by spectrally splitting the incident light and directing the appropriate portions of it to the proper cells, they have improved overall system conversion efficiency.

A group at the Research Triangle Institute, Research Triangle Park, NC, recently achieved a significant advance with this approach. The group fabricated two spectrally tailored cells monolithically; the cells are deposited one on top of the other and internally connected so they operate in series, both optically and electrically (Fig 3).

This structure's layers are grown by liquid-phase epitaxy (LPE). The heavily doped connecting region acts as a tunnel diode, providing a low-impedance electrical

path between the two cells.

Researcher S M Bedair reports observing 15% conversion efficiencies in these experimental stacked cells, and he expects to achieve efficiencies of up to 30% within the next 2 yrs—a figure that makes this approach attractive despite its complexity.

As an added benefit, the stacked cells have an open-circuit voltage of 2V, compared with 0.7V for conventional silicon cells. As a result, they can deliver more power than the conventional units at a given current level.

Increasing concentration

Rather than reducing cell-manufacturing costs, several laboratories hope to meet the DOE's goals by taking a system-optimization approach. They aim at demonstrating cost effectiveness by utilizing extensive optical systems to

concentrate sunlight onto cells.

In such systems, because the cost of the cell is a relatively small part of total system cost, system designers can freely use highly efficient (though costly) cells; the stacked-cell concept could prove particularly well suited to these concentrator applications.

Researchers are also developing unusual new materials for solar-cell applications. For example, Energy Conversion Devices recently unveiled an amorphous (noncrystalline) material which it claims could serve as the basis for a low-cost class of cells. However, other solar-cell researchers find it difficult to evaluate the Troy, MI company's claims because it has failed to release sufficient data.

In another development, investigator M J Cohen of Rockwell International, Thousand Oaks, CA, has

reported on the development of the first polymer/GaAs Schottky-barrier cell—one with output voltages about 40% higher than those of metal/GaAs cells. The latter devices have also been investigated as low-cost replacements for silicon cells.

Is silicon doomed?

In light of all of these recent solar-cell developments, do single-crystal silicon cells have any future? Most researchers agree that these conventional cells will play a major interim role in energy conversion for at least the next 10 yrs; silicon technology has been refined considerably over the past 20 yrs, and a sizable industry already exists.

Which of these new technologies will dominate? Most observers agree that no one technology will "win"; instead, most expect several complementary approaches to develop. **EDN**

Switching-power-supply improvements will dominate Powercon 6

Sam Davis, Manager,
Western Editorial Office (S)

Power-conversion design techniques—many of them relating to switching supplies—will provide the main attraction at Powercon 6. Highlighting the more than 30 papers, 60 exhibits and several short courses will be "how-to" presentations on

- A 1-kW on-line switcher

- A simple method to correct switcher power factors from 0.6 to almost unity
- An 8048- μ P-controlled switcher
- Computer modeling of semiconductor power-supply components.

Innovative switcher design

The most important Powercon presentations could well be those describ-

ing a 1-kW (60V at 15A) on-line switching power supply that inherently eliminates pulsating currents in both its input and output. The unit thus requires no input filtering and no output-filter capacitor. This switcher is the first application of a concept—termed optimum topology—described in 1978 at Powercon 5 by Assistant Professor Slobodan Čuk of the Califor-

nia Institute of Technology, Pasadena.

Prof Ćuk, assisted by graduate students Loman Rensink, Art Brown and Shi-Ping Hsu, will report on such design considerations as component sizing, methods of driving the power switch and the choice of the switcher's transformer turns ratio. This last factor is the result of a tradeoff between the switcher's ON current and OFF voltage.

In a tutorial seminar scheduled for the day before the conference, Prof Ćuk

and Prof R D Middlebrook, also of Cal Tech, will explain how to model a switching converter and measure the magnitude and phase of the device's small-signal response in the presence of high switching noise. And because many engineers have trouble measuring these response parameters, according to Middlebrook, he and Ćuk will demonstrate on an actual power supply.

Middlebrook will also explain how to analyze the response-measurement results, and he will present a

small-signal model of the converter and regulator. Generally, he intends to show how designers can apply simple, physically interpretable analytic techniques to real circuits to obtain correspondingly simple, useful and practical design criteria.

Reduce line current

Another switching-supply-related paper will detail a dynamic power-factor (PF) correction technique that reduces line current below values possi-

Powercon 6: Who, what, when, where

Powercon 6 will be held May 1-4 at the Fountainebleau-Hilton Hotel in Miami Beach, FL. The conference is sponsored by Power Concepts Inc, a consulting and educational firm specializing in applied power-conversion technology, and will be chaired by the firm's president, Ronald I Birdsall.

You can obtain additional Powercon information by contacting Powercon 6, Box 5226, Ventura, CA 93003. Phone (805) 985-6978.

Tutorial short courses

In addition to its exhibits and papers, Powercon 6 will also offer a number of short courses oriented toward power-supply designers, including:

- A high-frequency-magnetics design course presented by members of the Magnetic Material Producers Association; it will focus on available magnetic materials and their limitations
- A course on high-frequency (over 400 kHz) converters that reduce the size and weight of subsystems usually required in a switcher (EDN, January 20, pg 44), delivered by Rudy Severns, VMOS applications manager at Intersil, Cupertino, CA

- A presentation on the causes of—and methods for controlling—EMI/RFI, by Edith Kamm, an EE at the Naval Ocean Systems Center, San Diego, CA
- A practical circuit-design technique for controlling a power supply's frequency response—including a simple method for transient-response design—shown by Bill Wise, president of WIC Inc and a member of the EE staff at Lawrence Livermore Labs, Livermore, CA
- A short course on power-supply testing presented by Robert Cox, VP of Autotest, San Antonio, TX, and Jim Burens, president of California DC, Westlake Village, CA.

The more than 60 exhibits at Powercon 6 will include such offerings as a demonstration of supply transient response using an electronic load by ACDC Electronics; automated power-supply testing by Autotest; new VMOS power FETs by International Rectifier, El Segundo, CA; isolated-case power transistors by General Semiconductor Industries, Tempe, AZ; μ P power supplies by Texas Instruments, Dallas; Silicon General's power hybrids; a safe-operating-area transistor tester from Hewlett-Packard; and Cal Tech's 1-kW switcher.

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Technology News

ble with conventional off-line switchers. As described by Derek Chambers, engineering manager of Sorensen Co, Manchester, NH, the technique can raise a typical supply's power factor from 0.6 to 0.95. As a result of this

PF correction, a supply originally drawing 18A would draw only 14A—an additional benefit for electronic equipment obtaining its power from lines equipped with standard 15A circuit breakers.

Chambers explains that off-line single-phase switchers typically impose a nonlinear power-line load produced by their rectifier/filter-capacitor inputs. To correct for this nonlinearity, his firm utiliz-

POWERCON® 6 CONFERENCE PROGRAM

WED MAY 2		THURS MAY 3	FRI MAY 4
8:30	SESSION A: THE POWER SUPPLY AS A SYSTEM ELEMENT Optimizing minicomputer power-subsystem design Design techniques for controlling the point-of-load high-frequency performance of power supplies Design techniques to limit EMI in switching-mode converters	SESSION D: HIGH-VOLTAGE AND HIGH-POWER TECHNIQUES Optimizing boost-chopper charger design Design techniques for miniaturized spacecraft HV supplies Eliminating power-supply interaction with high-power pulsed loads	SESSION G: SWITCHED-MODE CONVERSION: REDUCING ANALYTICAL METHODS TO PRACTICE Optimizing passive-input filter design Computer-predicted steady-state stability of pulse-width-controlled dc/dc converters Modeling and design of the Cuk converter
10:30	BREAK	BREAK	BREAK
11:00	SESSION B: CIRCUIT DESIGN TECHNIQUES Designing nondissipative current snubbers for switched-mode converters A new, improved and simplified proportional base-drive circuit Dynamic power-factor correction in capacitor-input off-line converters	SESSION E: CIRCUIT AND FUNCTIONAL INTEGRATION Toward a high-frequency, universal power switch Simplifying switching-regulator applications with a new class of self-contained hybrid regulators Functional power-conditioning modules: new building blocks for converter design	SESSION H: NEW DESIGN METHODS AND CONVERTER CONFIGURATIONS A μ P-controlled VMOS power supply Designing the off-line, high-efficiency venable converter Design of a kilowatt off-line switcher using a Cuk converter
1:00	LUNCH BREAK	POWERCON 6 LUNCHEON	LUNCH BREAK
3:00 TO 5:00	SESSION C: SEMICONDUCTORS FOR POWER CONVERSION Simplifying predictable converter design with CAD power-semiconductor models Using high-voltage power MOSFETs in off-line converter applications Applying ultrafast power thyristors in high-frequency-converter design	SESSION F: NEW DESIGN METHODS AND CONVERTER CONFIGURATIONS Reducing magnetic component size with reverse-biased ferrite cores A new PWM control technique that eliminates transformer-unbalance problems in power converters Designing improved high-frequency dc/dc converters with a new resonant thyristor technique A new technique for simplifying sine-wave-synthesis inverter design	SESSION I: SPECIAL POWER-CONVERSION TOPICS: ENERGY SYSTEMS AND RELIABILITY Optimizing solar photovoltaic power-system design Design techniques for achieving high reliability in switched-mode converters The effects of operating parameters on aluminum electrolytic capacitor reliability in switched-mode converters Factors affecting the application reliability of Schottky rectifiers
6:00 TO 7:30	INDUSTRY-SPONSORED COCKTAIL PARTY		

PROFESSIONAL ADVANCEMENT SEMINAR PROGRAM

TUES MAY 1	WED MAY 2	THURS MAY 3	FRI MAY 4
9:00 AM TO 5:00 PM Modeling and measurement of dc/dc switching converters and regulators <i>Dr R D Middlebrook and Dr Slobodan Cuk, California Institute of Technology</i>	2:00 PM TO 5:30 PM A simplified technique for achieving predictable closed-loop performance <i>W L Wise, Lawrence Livermore Laboratory, and president, WIC Inc</i>	8:30 AM TO 12:00N Designing very high-frequency VMOS FET converters <i>Rudolf Severns, VMOS applications manager, Intersil</i>	2:00 PM TO 5:30 PM Predicting and controlling EMI in state-of-the-art power converters <i>Edith Kamn, electronic engineer, Naval Ocean Systems Center</i>
9:00 AM TO 1:00 PM The "business end" of the business: market awareness <i>Chairman: Robert Boschert, President, Boschert Inc</i>			2:00 PM TO 5:30 PM Production verification of power-converter performance <i>Robert Cox, Autotest; James Burens, California DC; and Scott Noltenmeier, Intel</i>

There's much to be said about the Harris HM-6100 12-bit CMOS microprocessor system. Micro-12 says it all.

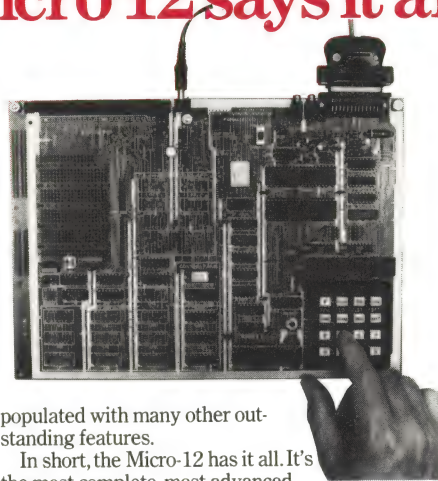
Sooner or later, you're going to evaluate the HM-6100 CPU family. You can do it now, simply and at low cost, with the new Harris Micro-12 printed circuit board. Fully assembled and tested, the compact Micro-12 is a complete CMOS system including the HM-6100 CPU, ROM and RAM memory, UART and Parallel I/O Port.

IC's produced with the Harris silicon-gate CMOS technology permit high speed, low power operation using inexpensive batteries.

Also, the HM-6100 emulates the software operation of the proven and widely used PDP-8/E* minicomputer. Other benefits include the use of new, low cost PDP-8 development systems, like the DECstation 78* and easy-to-program single-word instructions that significantly reduce development time.

Understanding of the Harris HM-6100 instruction set will come easily with the Micro-12. Uniquely, it interfaces with a teletype, CRT terminal or tape cassette. And its 8-digit display and 16-key keyboard are interactive, allowing direct program insertion, execution and examination.

For program debug, the Micro-12 has a system monitor with four independent breakpoints. Program memory includes a 256 x 12 RAM with space provided for expansion to 1K x 12, and the board—about the size of a magazine page—is



populated with many other outstanding features.

In short, the Micro-12 has it all. It's the most complete, most advanced CMOS microprocessor support system available in the industry. And it's easy to use.

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Meantime, you can learn more about the Micro-12 and the HM-6100 family by calling

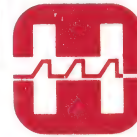
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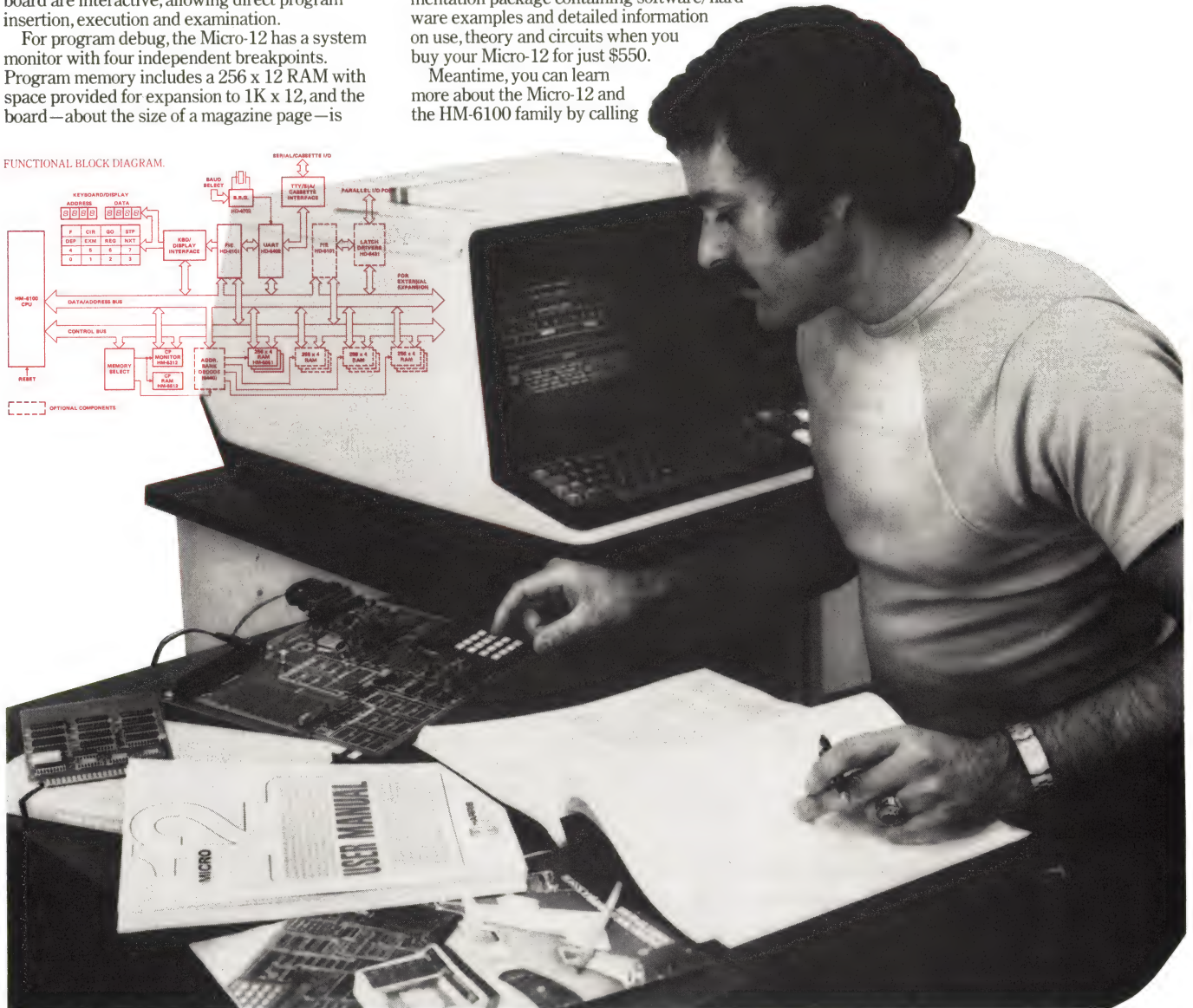
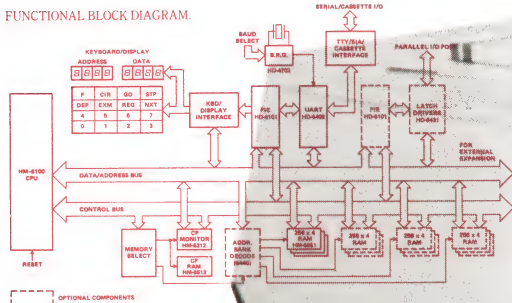
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es switching transistors and magnetic components that supply power from the line to the filter capacitor when the line voltage reaches about 30% of its peak value.

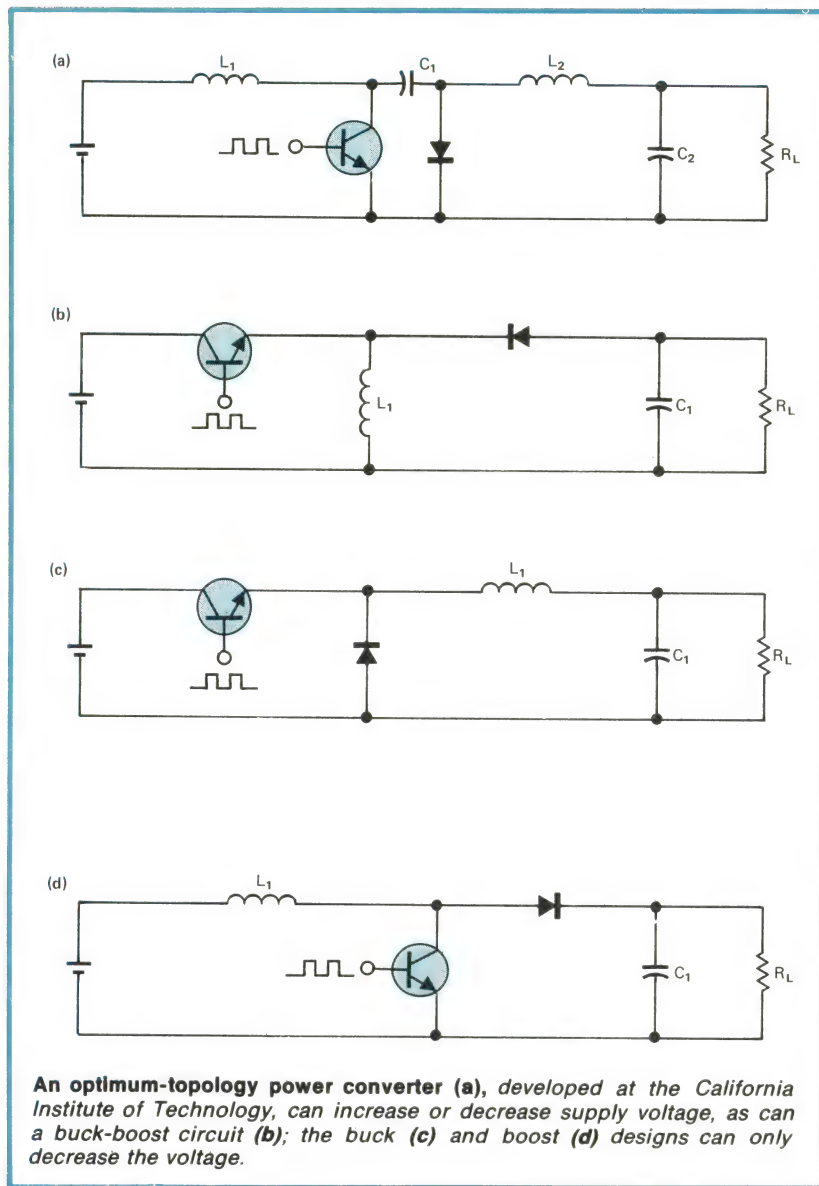
As a result, the capacitor current stays nearly in phase with the applied voltage for most of the power cycle; hence the supply's power factor improves almost to unity.

Sophisticated control

Another method of improving switching-supply performance utilizes an 8048 μ P, a PROM and a DAC to control a supply's regulation loop. Applications engineer Dave Hoffman, of Siliconix, Santa Clara, CA, will explain this control method, which also includes a firmware filtering algorithm to reduce line ripple.

The Siliconix unit's μ P generates a reference voltage (via the DAC) that's compared with the supply's output voltage. The comparator output then feeds back to the μ P, which responds with pulse-width-modulated control for the supply's VMOS power-FET switches. Thus, the system even allows keyboard control of the supply's output-voltage and waveform characteristics.

Pulse-width modulation also eliminates transformer-imbalance problems in a switching supply scheduled for presentation by Walt Hirschberg, VP for product development at ACDC Electronics, Ocean-side, CA. He notes that these transformer imbalances can result from load-current modulation near the switching frequency and can cause



An optimum-topology power converter (a), developed at the California Institute of Technology, can increase or decrease supply voltage, as can a buck-boost circuit (b); the buck (c) and boost (d) designs can only decrease the voltage.

internal-component failure.

Building blocks


Circuit designers who would rather avoid some of the tedious component-level considerations associated with assembling a switcher might find an alternative in a family of switching-supply building blocks to be introduced at the show by Silicon General, Garden Grove, CA. Housed in 10-pin, $2.5 \times 1.5 \times 0.3$ -in. modules, these units can save assem-

bly time and money, as well as making RFI control easier because of their small size, according to applications manager Pete Wood. The hybrid modules dissipate up to about 3W—a figure made possible by a proprietary substrate with low thermal impedance.

One of the four modules contains a controlled phase-angle rectifier that charges an external input-filter capacitor to prevent large inrush currents. Another

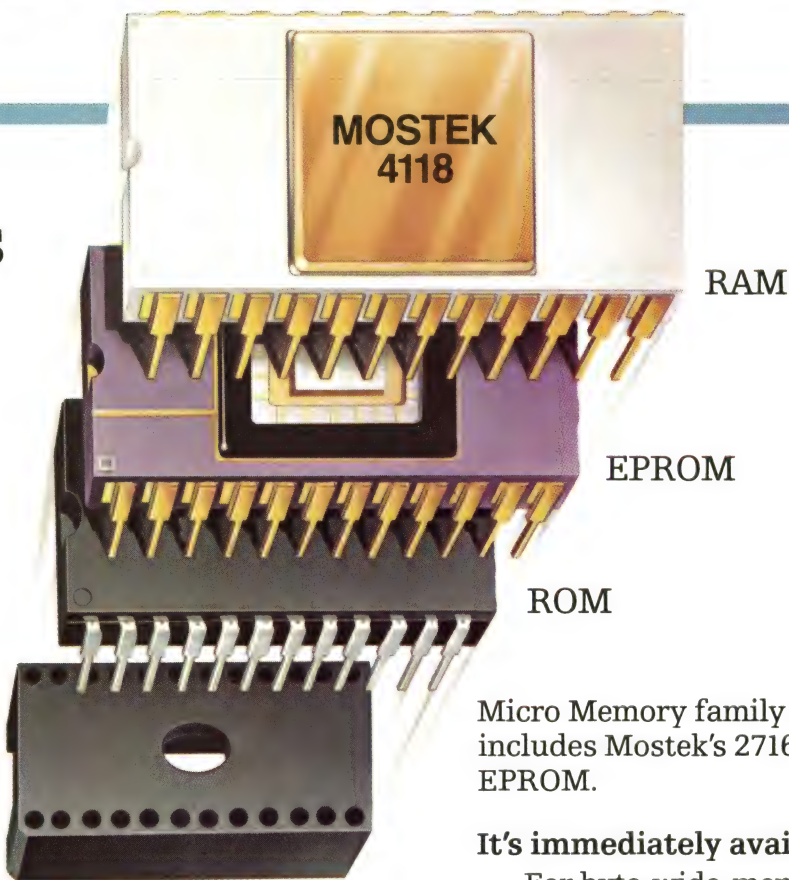
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module—a power-stage unit—accepts unregulated dc inputs from 100 to 400V at 10A; it operates between 50 and 100 kHz. The switching system's transformer and the output rectifier and filter are all external.

A bias-converter module supplies low-voltage power for the switching system's regulator circuit (which consists primarily of an SG1525 regulator IC). This low-power module operates from unregulated dc and produces a regulated output between 15 and 20V. The fourth module, a drive circuit still in development, amplifies the regulator IC's output to drive the power module.

Computer models help

A design-oriented Powercon paper that isn't restrict-

ed to switching power supplies will focus on the computer modeling of semiconductor power-supply components. Dr James Bowers, a professor at the University of South Florida in Tampa, will present a brief description of available computer-analysis programs, then describe his technique for measuring a power semiconductor's parameters, establishing its equivalent circuit and developing a corresponding computer model.

Dr Bowers and his colleagues have developed models for hundreds of diodes, SCRs, bipolar and MOSFET transistors, and integrated power op amps.

Engineers can use these models to save time and money when designing

power supplies, says Bowers. He notes that although a special device can often take 6 to 8 wks to obtain, an engineer using its computer model can accurately design a power-supply circuit on paper before receiving the part itself.

The models can also help determine a supply's worst-case design. "The computer model allows a variation of parameters—such as beta or collector current—and helps determine their impact on the circuit," Bowers notes. "There is no practical way to duplicate all the possible variations using the actual components." And, he adds, "We have never found a mistake in our computer-analysis technique." **EDN**

64-pin-chip packaging developers offer an alternative to JEDEC standard

Bob Peterson,
Associate Editor

Two manufacturers have joined forces to introduce a 64-pin quad-in-line packaging (QUIP) system that—compared with an equivalent DIP—saves pc-board space while still allowing easy access to the IC's pins for testing purposes. And although this packaging arrangement does not conform to the standardization guidelines proposed by JEDEC for space-saving IC packages (EDN, Sept 20,

1978, pg 119), it does offer certain advantages.

Developed jointly by Intel Corp, Aloha, OR, and 3M Co, St Paul, MN, the QUIP system consists of three parts: a zero-insertion-force socket with four rows of standard pins on 100-mil centers, a leadless ceramic chip carrier with two rows of leads on 50-mil centers and a metal clip that holds the chip carrier's contacts against the socket's contacts. The clip also helps dissipate heat generated by the chip.

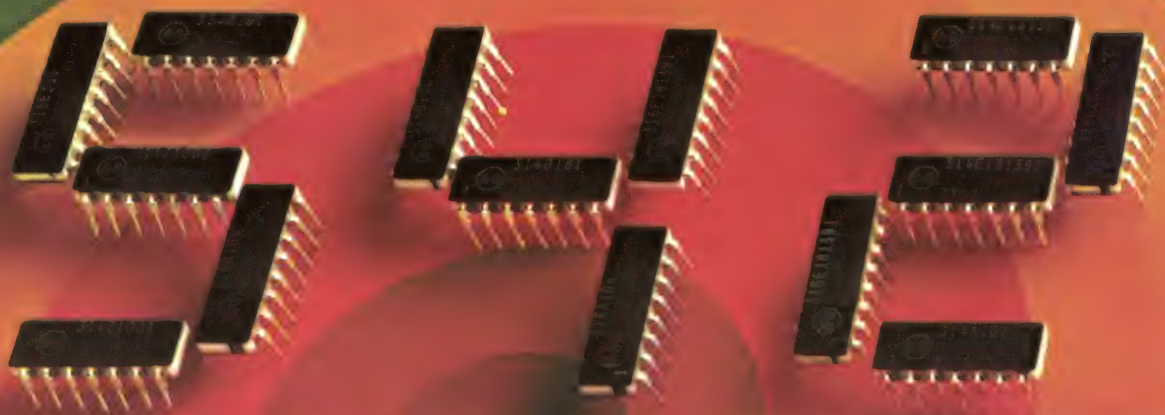
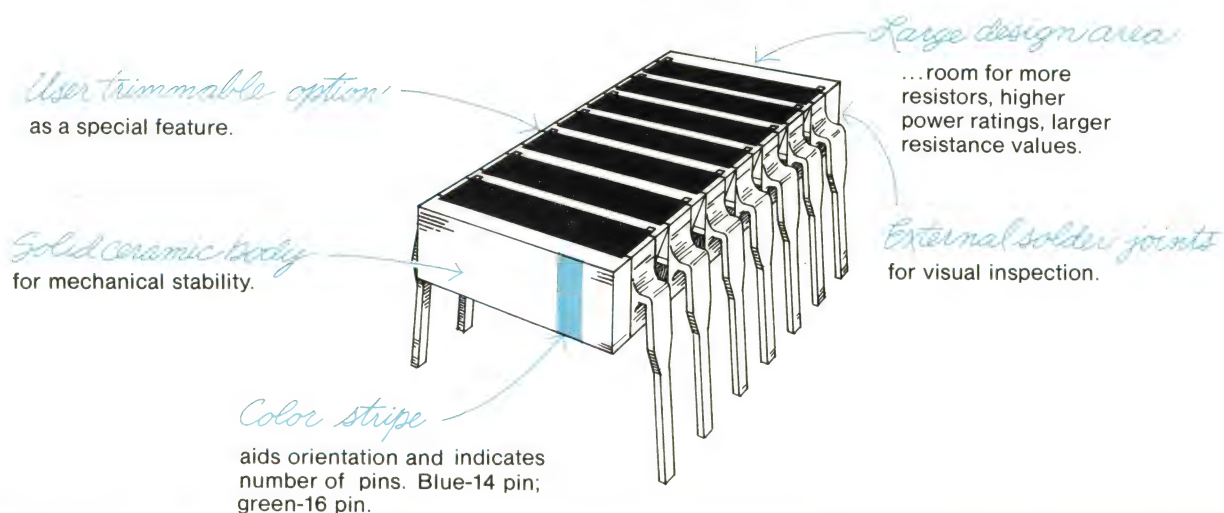
While the 64-pin QUIP

requires less pc-board area than a DIP (2.1 vs 3.5 in.², respectively), the closest equivalent package suggested by JEDEC requires even less board area (1.4 in.² for a 68-pin device). On double-sided pc boards, however, the QUIP can save space by allowing designers to run traces between its leads. And because it also permits use of standard wave-soldering techniques in board fabrication, the QUIP can serve, in many cases, as an economical packaging scheme. **EDN**

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Versatile optoisolators, couplers move into new applications

Robert Grossman, Manager,
Western Editorial Office (N)

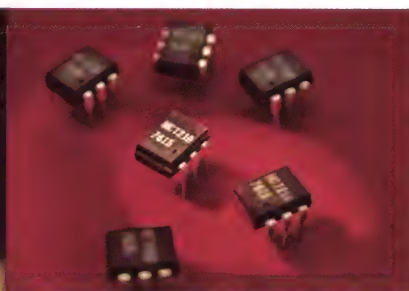
Optoelectronic isolators and couplers are replacing the slow and bulky electromechanical devices that previously isolated delicate circuitry—especially in telecommunications, which constitutes the devices' biggest market, according to an assessment by the top three suppliers. And as optoisolators mature in complexity and capability, they could become commonplace in all kinds of digital equipment.

With the increase in distributed processing, for example, optoisolators have taken on a new importance



Designed for high-performance applications, H-P's HCPL2601 provides 3000V isolation, with a 70% typical current-transfer ratio (I_c/I_o).

to the computer industry. Optical devices can prevent unwanted interaction among any physically separable parts of a computer system—such as CRT terminals or printers—as well as isolating a system from the



Offering up to 2500V-dc surge isolation, Monsanto's MCT210 optoisolator drives up to 200 mW with an output-phototransistor collector-to-emitter voltage of 30V max.

outside world.

Industrial-noise solution

Industrial environments can present a very harsh "outside world" to a process-control computer; noise and damaging tran-

Illuminating the market

The steady growth of the optoisolator market indicates the importance and versatility of these products. Specifically, Monsanto's marketing manager for optoelectronic products, Bill Bottini, pegs the 1978 market for optoisolators at \$41 million—a figure supported by Hewlett-Packard's optocoupler product manager, Gary Labelle. Both men see a steady 20 to 25% annual market growth in the next few years.

Semiconductor houses such as Motorola, Fairchild and Texas Instruments are challenging the three optoisolator market leaders—General Electric, Hewlett-Packard and Monsanto—for a larger share of the market. The leaders are also feeling the increasing presence of smaller companies—Spectronics, Optron and Litronix, for example.

With regard to the leaders' overall marketing philosophy, GE, for one, does not intend to produce single-function parts for specialized industries. Joe McSweeney, the firm's

optoelectronic product planner, states that GE's product line will have a "broad-based market." With this strategy, the company hopes to continue its growth in industries where the trend is toward solid-state components and away from mechanical ones.

Monsanto sees optoisolators as common, reliable devices that designers can now utilize even when they are not absolutely required. This manufacturer feels that its growth in the optoelectronics field will be tied to the continuing computerization of American factories.

In contrast to the other market leaders, H-P has concentrated its efforts on the high end of the market. While all optocouplers employ some form of hybrid bipolar processing, H-P has designed its products to allow even more integration than usual on one chip. "Most devices have had to compromise performance between speed and efficient light capture," according to Labelle. "We combined the amplifier and optocoupler on the same chip for high-speed performance up to 10M bps."



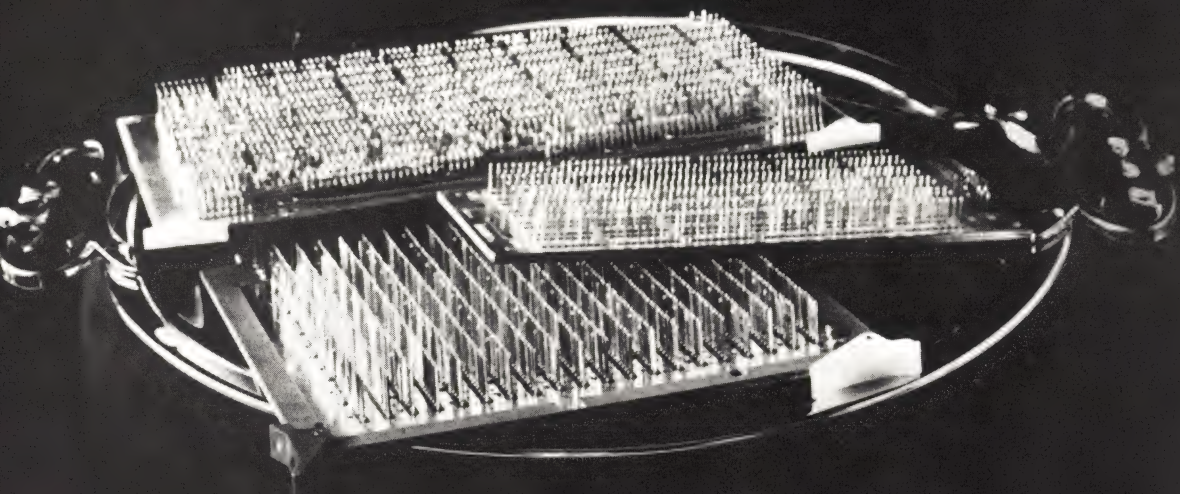
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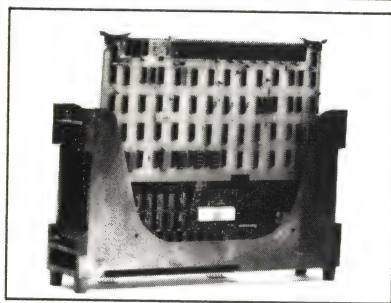
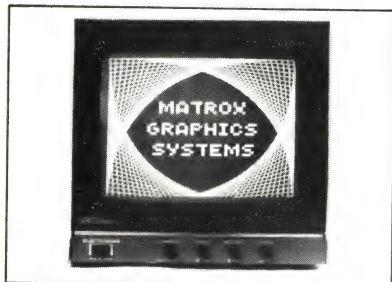


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Technology News

sients abound. Inserted between digital circuitry and this ac environment, optoisolators provide inexpensive circuit protection and permit control of high-current devices such as SCRs and triacs.

One potentially important industrial market that optoisolators have *not* yet entered is the automotive business. As electronic engine control becomes more prevalent (EDN, March 5, pg 37), Detroit might turn to inexpensive optical isolators as a solution to electrical-noise problems. For now, though, most optoisolators operate from 5V supplies rather than 12V, and Detroit's designers have other problems—such as emission control—on their minds, so penetration of the auto market remains but a possibility for optoelectronics.

Coupler or isolator?

Most of the current and prospective application areas utilize two separate capabilities of optoelectronic devices: coupling and isolating. Whereas *optocouplers* simply form an interface between two electrically independent circuits (configured from two incompatible logic families such as TTL and CMOS, for example), *optoisolators* must protect a circuit from potentially damaging voltage transients.

In reality, though, the only difference between opto-

isolators and optocouplers is one provided by marketing gamesmanship. Basically the same device, these optoelectronic components change names to suit the particular market segment in question.

Letting the light in

In its simplest form, an optoisolator/optocoupler contains two active devices on one die: an LED and a photodetector. The LED is fabricated in a standard manner. But it doesn't have an exposed emitting element; all of its light is directed onto the enlarged base region of the photodetector. Thus, when the isolator's input signal modulates the LED's light level, the photodetector senses the changes, and the input signal—now electrically isolated from the input—appears at the output.

Most of the actual differences between devices on the market stem from different output-stage designs. Most outputs utilize a 3-terminal semiconductor with one of its terminals (depending on semiconductor type) replaced by a photodetector: If a phototransistor is used, the photodetector replaces the transistor's base, while phototriacs and SCRs substitute the detector for their triggers. Some output stages also employ Darlington amplifiers to boost signal levels.

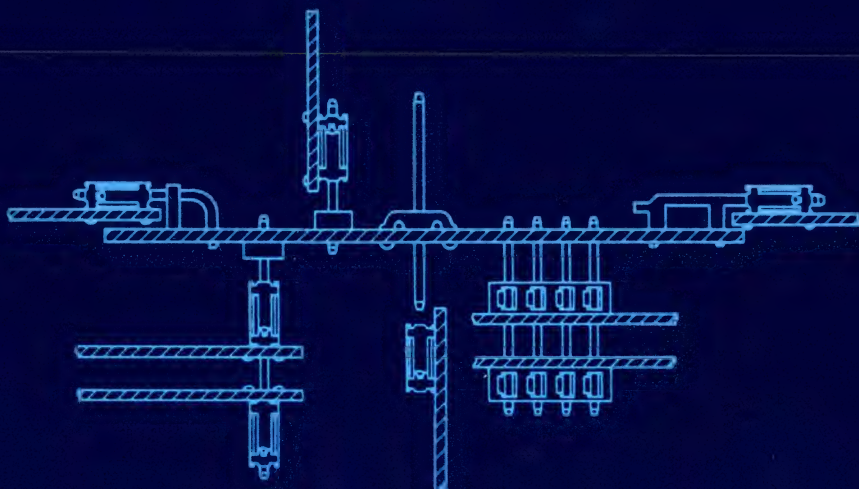
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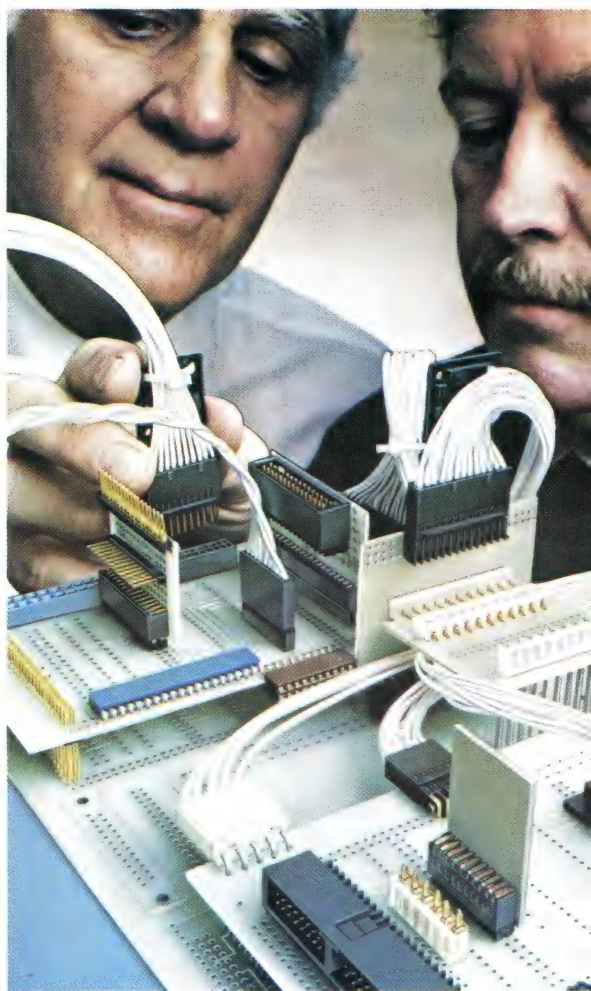
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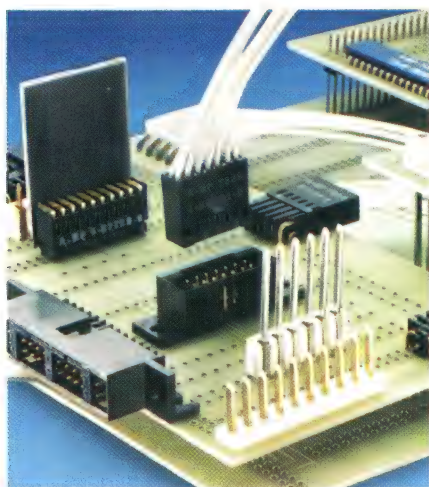
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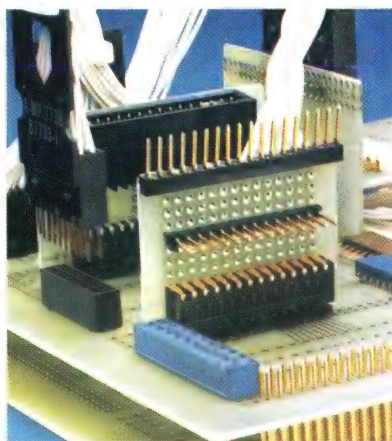
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Some facts worth knowing about AMPMODU connectors

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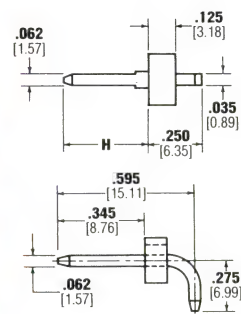


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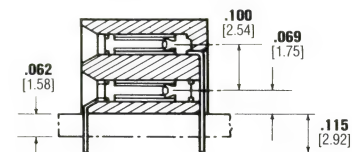
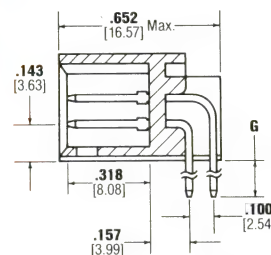
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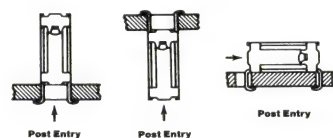
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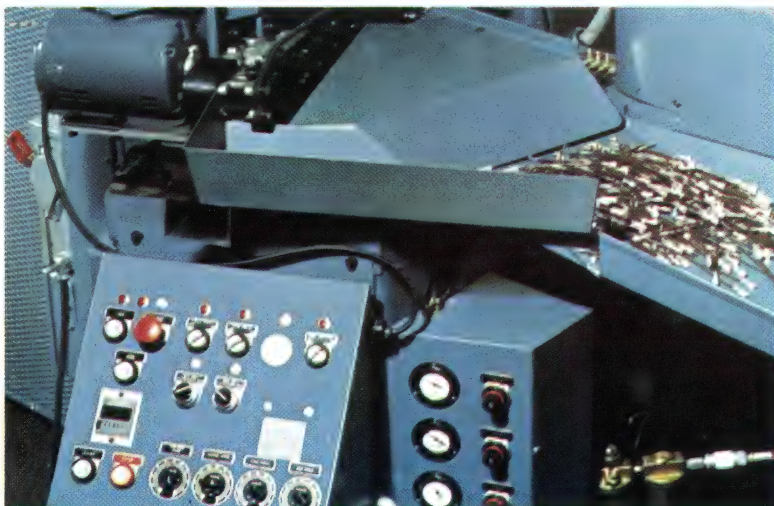
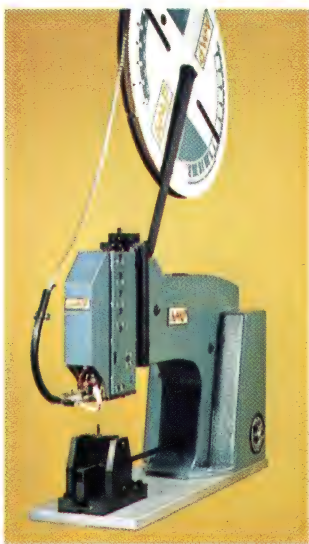


2. Headers for .025" x .025" technology



3. Board mount receptacle configurations

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AMP

μ Computerist Corner

Simple circuit multiplies in 800 nsec

Prakash Dandekar

Andhra Valley Power Supply, Bombay, India

Currently available NMOS μ Ps require relatively long times (200 μ sec and more) to perform a multiplication; for high-speed control and signal-processing applications, designers usually opt for an expensive multiplier chip or a bipolar μ P to achieve times faster than this. You can reduce the multiplication bottleneck, however, by using a separate hardware subsystem interfaced to the μ P. The design presented here requires about 20 MSI/SSI ICs and costs less than \$30. With ordinary 7400 Series TTL, its highest usable clock frequency of 10 MHz permits 800-nsec 8-bit multiplication.

The subsystem (Fig 1) uses the simple shift-and-add algorithm flowcharted in Fig 2. The

hardware consists of two 8-bit operand registers accessible to the μ P (X and Y), a 16-bit result register (Z) and a counter that controls the multiplication sequence. Interfacing to a μ P system is simple: DEVSEL X and DEVSEL Y are two strobes generated by decoding the system address lines. These two signals load the X and Y registers; DEVSEL Y also clears the subsystem and starts the multiplication. Upon completion of the operation, the DONE flag goes HIGH; this flag is used by an interrupt-driven system.

The system clock period should be sufficiently long to provide a delay between the shifting-X and strobing-Z operations. The period must include the maximum clock-to-output delay of the 7495, the ripple-carry delay of the 7483 and the setup time and propagation delay of the 74175. Use of standard TTL permits a clock period of 100 nsec and thus a multiplica-

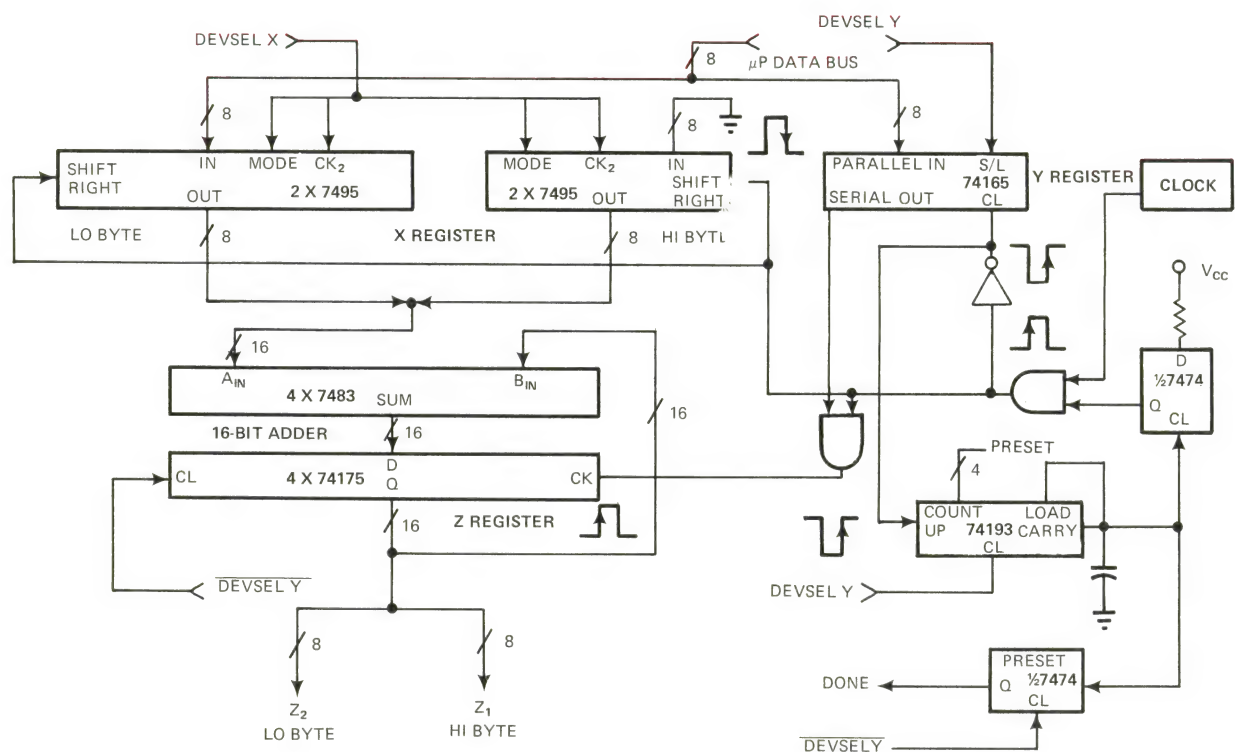


Fig 1—With careful selection of edge-triggered devices, this circuit performs an 8×8-bit multiplication in 800 nsec.

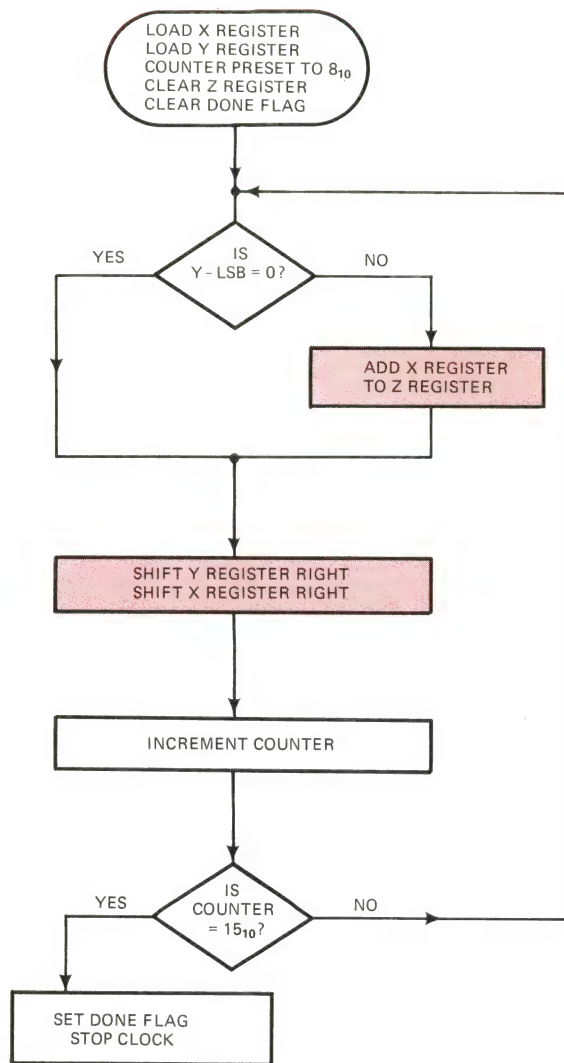


Fig 2—A shift-and-add algorithm makes the subsystem go.

tion time of 800 nsec.

Because most instructions of an NMOS μ P require 2 to 10 μ sec, an 800-nsec multiplication time represents engineering overkill. In such cases, you can use a lower clock frequency—using the CPU clock for this purpose saves circuitry.

In a typical 8080A-interfaced application, the X, Y, Z₁ and Z₂ registers are assigned consecutive memory locations; the X and Y operands are in the B and C registers, respectively. Use the code in Fig 3 to perform the multiplication; the 2-byte result is stored in DE.

The multiplication routine requires about 22 μ sec, compared with an all-software multipli-

```

MULT: LXI  H, X      ; X-register address loaded
                        ; in (H, L) pair
      MOV  M, B      ; X loaded
      INX  H          ; (H, L) incremented
      MOV  M, C      ; Y loaded, multiplication
      INX  H          ; proceeds
      MOV  D, M      ; Z1 (high-byte of result)
                        ; is brought into D register
      INX  H          ; address of Z2 register
      MOV  E, M      ; low-byte of result in E
      RET              ; register
  
```

Fig 3—Use this code when interfacing the multiplier with an 8080A system.

cation time of about 230 μ sec. Close examination of the routine reveals that the time between the loading of the Y register and the retrieval of the high byte from Z₁ is about 4 μ sec (eight microcycles at a 2-MHz clock frequency). Thus, using the 8080A's ϕ_2 clock, the subsystem clock frequency can be lowered so that the operation takes at most 4 μ sec.

This basic multiplier can be expanded to handle two 16-bit words. But in a hardwired system, the X, Y and Z registers double in width and thereby increase component count. If board space or parts cost is important, use the 8-bit subsystem as a byte multiplier together with an expanded software routine. **EDN**

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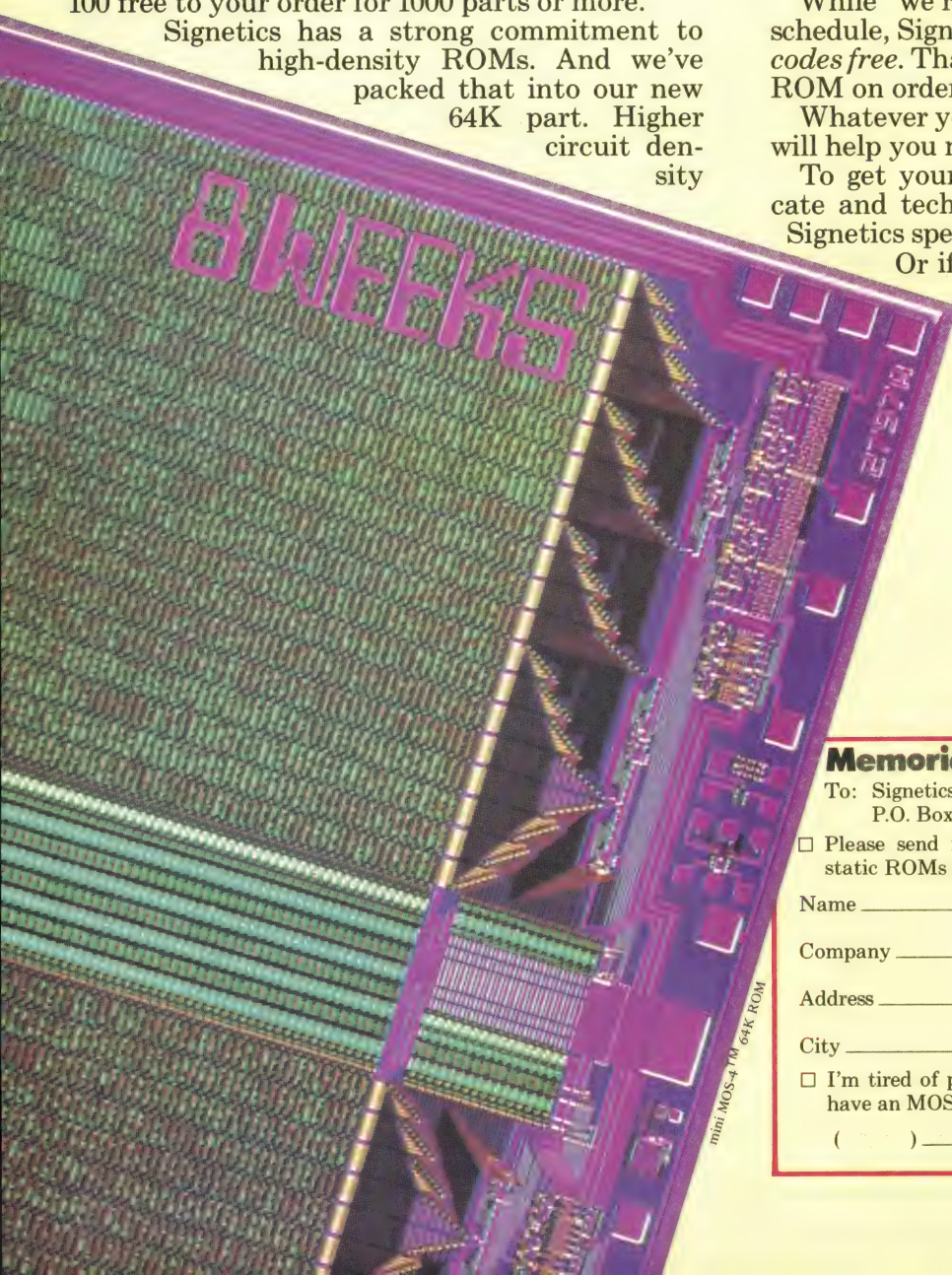
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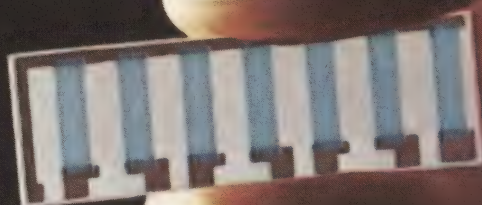
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EDN Software Note #27

Execute MK3870 magnitude comparisons

Don Ward

Mostek Corp, Carrollton, TX

By testing the appropriate status bit(s) of an MK3870, you can make magnitude comparisons without altering the contents of the device's accumulator or memory.

The μC's instruction set provides two comparison instructions which do not store a result: CI (compare immediate) and CM (compare memory). These instructions add the two's-complement value of the accumulator to the immediate byte (CI) or to the memory byte (CM) referenced by the data counter. Although a comparison's result is discarded, the operation alters the status register according to the rules of two's-complement addition.

For two numbers, A and B (signed or unsigned magnitudes), the **table** indicates the status conditions necessary for each comparison.

RELATION	UNSIGNED	SIGNED
	O Z C S	O Z C S
A = B	- 1 - -	- 1 - -
A <> B	- 0 - -	- 0 - -
A > B	- - 0 -	0 - - 0 or 1 - - 1
A <= B	- - 1 -	0 - - 1 or 1 - - 0
A < B	- 0 1 -	1 - - 0 or 0 0 - 1
A >= B	- - 0 - or - 1 - -	0 - - 0 or 1 - - 1 or - 1 - -

A magnitude comparison in an MK3870 sets testable status conditions. A "-" in this reference table indicates a "don't-care" bit.

son. The routines in the **figure** test for each condition and perform a branch if the relation is true. Although these routines use CI, CM can be substituted for memory comparison.

EDN

```

>0000      0007 B      EQU      H'00'      ASSIGN B TO SOME VALUE.
           0008 *
           0009 * (A)  A = B
           0010 *      Same as Example 1.0 (A).
           0011 *
           0012 *
           0013 *
           0014 * (B)  A <> B
           0015 *      Same as Example 1.0 (B).
           0016 *
           0017 *
           0018 *
           0019 * (C)  A > B
'0000 2500      0020      CI      B      COMPARE VALUES.
'0002 990E      0021      BF      9,AGTB  BRANCH IF OVFS=0.
'0004 9803      0022      BNO     ALEB    S=1 IF OVFS=0.
'0006 810A      0023      BP      AGTB    BRANCH IF OVFS=1.
'0008 2B        0024 ALEB      NOP      FLOW HERE IF OVFS=1, S=0.
           0025 *
           0026 *
           0027 *
           0028 * (D)  A <= B
'0009 2500      0029      CI      B
'000B 9905      0030      BF      9,AGTB  BRANCH IF OVFS=0.
'000D 98FA      0031      BNO     ALEB    S=1 IF OVFS=0.
'000F 91F8      0032      BM      ALEB    BRANCH IF S <> 0.
'0011 2B        0033 AGTB      NOP      CONTINUE HERE IF OVFS=S.
           0034 *
           0035 *
           0036 *
           0037 * (E)  A < B
'0012 2500      0038      CI      B

```

In this code for signed and unsigned magnitude comparisons, "A" represents the accumulator and "B" the comparison value. (Continued on next page)

μComputerist Corner

'0014	9905	0039	BF	9,AGEB	BRANCH IF OVF=S=0.
'0016	9C0C	0040	BF	12,ALTB	BRANCH IF OVF=Z=0.
'0018	910A	0041	BM	ALTB	BRANCH IF S=Z=0.
'001A	2B	0042	AGEB	NOP	CONTINUE HERE IF OVF=S
		0043	*		OR Z=1.
		0044	*		
		0045	*		
		0046	*		
		0047	*(F)	A >= B	
'001B	2500	0048	CI	B	
'001D	99FC	0049	BF	9,AGEB	BRANCH IF OVF=S=0.
'001F	9C03	0050	BF	12,ALTB	BRANCH IF OVF=Z=0.
'0021	81F8	0051	BF	AGEB	BRANCH IF S=1.
'0023	2B	0052	ALTB	NOP	CONTINUE HERE IF C <> S
		0053	*		AND Z=0.
		0054	*		
		0055	*		
		0056	*(F)	A >= B	
		0057	CI	B	
		0058	BF	9,AGEB	BRANCH IF OVF=S=0.
		0059	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0060	BF	AGEB	BRANCH IF S=1.
		0061	ALTB	NOP	CONTINUE HERE IF C <> S
		0062	*		AND Z=0.
		0063	*		
		0064	*(F)	A >= B	
		0065	CI	B	
		0066	BF	9,AGEB	BRANCH IF OVF=S=0.
		0067	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0068	BF	AGEB	BRANCH IF S=1.
		0069	ALTB	NOP	CONTINUE HERE IF C <> S
		0070	*		AND Z=0.
		0071	*		
		0072	*(F)	A >= B	
		0073	CI	B	
		0074	BF	9,AGEB	BRANCH IF OVF=S=0.
		0075	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0076	BF	AGEB	BRANCH IF S=1.
		0077	ALTB	NOP	CONTINUE HERE IF C <> S
		0078	*		AND Z=0.
		0079	*		
		0080	*(F)	A >= B	
		0081	CI	B	
		0082	BF	9,AGEB	BRANCH IF OVF=S=0.
		0083	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0084	BF	AGEB	BRANCH IF S=1.
		0085	ALTB	NOP	CONTINUE HERE IF C <> S
		0086	*		AND Z=0.
		0087	*		
		0088	*(F)	A >= B	
		0089	CI	B	
		0090	BF	9,AGEB	BRANCH IF OVF=S=0.
		0091	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0092	BF	AGEB	BRANCH IF S=1.
		0093	ALTB	NOP	CONTINUE HERE IF C <> S
		0094	*		AND Z=0.
		0095	*		
		0096	*(F)	A >= B	
		0097	CI	B	
		0098	BF	9,AGEB	BRANCH IF OVF=S=0.
		0099	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0100	BF	AGEB	BRANCH IF S=1.
		0101	ALTB	NOP	CONTINUE HERE IF C <> S
		0102	*		AND Z=0.
		0103	*		
		0104	*(F)	A >= B	
		0105	CI	B	
		0106	BF	9,AGEB	BRANCH IF OVF=S=0.
		0107	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0108	BF	AGEB	BRANCH IF S=1.
		0109	ALTB	NOP	CONTINUE HERE IF C <> S
		0110	*		AND Z=0.
		0111	*		
		0112	*(F)	A >= B	
		0113	CI	B	
		0114	BF	9,AGEB	BRANCH IF OVF=S=0.
		0115	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0116	BF	AGEB	BRANCH IF S=1.
		0117	ALTB	NOP	CONTINUE HERE IF C <> S
		0118	*		AND Z=0.
		0119	*		
		0120	*(F)	A >= B	
		0121	CI	B	
		0122	BF	9,AGEB	BRANCH IF OVF=S=0.
		0123	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0124	BF	AGEB	BRANCH IF S=1.
		0125	ALTB	NOP	CONTINUE HERE IF C <> S
		0126	*		AND Z=0.
		0127	*		
		0128	*(F)	A >= B	
		0129	CI	B	
		0130	BF	9,AGEB	BRANCH IF OVF=S=0.
		0131	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0132	BF	AGEB	BRANCH IF S=1.
		0133	ALTB	NOP	CONTINUE HERE IF C <> S
		0134	*		AND Z=0.
		0135	*		
		0136	*(F)	A >= B	
		0137	CI	B	
		0138	BF	9,AGEB	BRANCH IF OVF=S=0.
		0139	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0140	BF	AGEB	BRANCH IF S=1.
		0141	ALTB	NOP	CONTINUE HERE IF C <> S
		0142	*		AND Z=0.
		0143	*		
		0144	*(F)	A >= B	
		0145	CI	B	
		0146	BF	9,AGEB	BRANCH IF OVF=S=0.
		0147	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0148	BF	AGEB	BRANCH IF S=1.
		0149	ALTB	NOP	CONTINUE HERE IF C <> S
		0150	*		AND Z=0.
		0151	*		
		0152	*(F)	A >= B	
		0153	CI	B	
		0154	BF	9,AGEB	BRANCH IF OVF=S=0.
		0155	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0156	BF	AGEB	BRANCH IF S=1.
		0157	ALTB	NOP	CONTINUE HERE IF C <> S
		0158	*		AND Z=0.
		0159	*		
		0160	*(F)	A >= B	
		0161	CI	B	
		0162	BF	9,AGEB	BRANCH IF OVF=S=0.
		0163	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0164	BF	AGEB	BRANCH IF S=1.
		0165	ALTB	NOP	CONTINUE HERE IF C <> S
		0166	*		AND Z=0.
		0167	*		
		0168	*(F)	A >= B	
		0169	CI	B	
		0170	BF	9,AGEB	BRANCH IF OVF=S=0.
		0171	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0172	BF	AGEB	BRANCH IF S=1.
		0173	ALTB	NOP	CONTINUE HERE IF C <> S
		0174	*		AND Z=0.
		0175	*		
		0176	*(F)	A >= B	
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		0178	BF	9,AGEB	BRANCH IF OVF=S=0.
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		0180	BF	AGEB	BRANCH IF S=1.
		0181	ALTB	NOP	CONTINUE HERE IF C <> S
		0182	*		AND Z=0.
		0183	*		
		0184	*(F)	A >= B	
		0185	CI	B	
		0186	BF	9,AGEB	BRANCH IF OVF=S=0.
		0187	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0188	BF	AGEB	BRANCH IF S=1.
		0189	ALTB	NOP	CONTINUE HERE IF C <> S
		0190	*		AND Z=0.
		0191	*		
		0192	*(F)	A >= B	
		0193	CI	B	
		0194	BF	9,AGEB	BRANCH IF OVF=S=0.
		0195	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0196	BF	AGEB	BRANCH IF S=1.
		0197	ALTB	NOP	CONTINUE HERE IF C <> S
		0198	*		AND Z=0.
		0199	*		
		0200	*(F)	A >= B	
		0201	CI	B	
		0202	BF	9,AGEB	BRANCH IF OVF=S=0.
		0203	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0204	BF	AGEB	BRANCH IF S=1.
		0205	ALTB	NOP	CONTINUE HERE IF C <> S
		0206	*		AND Z=0.
		0207	*		
		0208	*(F)	A >= B	
		0209	CI	B	
		0210	BF	9,AGEB	BRANCH IF OVF=S=0.
		0211	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0212	BF	AGEB	BRANCH IF S=1.
		0213	ALTB	NOP	CONTINUE HERE IF C <> S
		0214	*		AND Z=0.
		0215	*		
		0216	*(F)	A >= B	
		0217	CI	B	
		0218	BF	9,AGEB	BRANCH IF OVF=S=0.
		0219	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0220	BF	AGEB	BRANCH IF S=1.
		0221	ALTB	NOP	CONTINUE HERE IF C <> S
		0222	*		AND Z=0.
		0223	*		
		0224	*(F)	A >= B	
		0225	CI	B	
		0226	BF	9,AGEB	BRANCH IF OVF=S=0.
		0227	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0228	BF	AGEB	BRANCH IF S=1.
		0229	ALTB	NOP	CONTINUE HERE IF C <> S
		0230	*		AND Z=0.
		0231	*		
		0232	*(F)	A >= B	
		0233	CI	B	
		0234	BF	9,AGEB	BRANCH IF OVF=S=0.
		0235	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0236	BF	AGEB	BRANCH IF S=1.
		0237	ALTB	NOP	CONTINUE HERE IF C <> S
		0238	*		AND Z=0.
		0239	*		
		0240	*(F)	A >= B	
		0241	CI	B	
		0242	BF	9,AGEB	BRANCH IF OVF=S=0.
		0243	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0244	BF	AGEB	BRANCH IF S=1.
		0245	ALTB	NOP	CONTINUE HERE IF C <> S
		0246	*		AND Z=0.
		0247	*		
		0248	*(F)	A >= B	
		0249	CI	B	
		0250	BF	9,AGEB	BRANCH IF OVF=S=0.
		0251	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0252	BF	AGEB	BRANCH IF S=1.
		0253	ALTB	NOP	CONTINUE HERE IF C <> S
		0254	*		AND Z=0.
		0255	*		
		0256	*(F)	A >= B	
		0257	CI	B	
		0258	BF	9,AGEB	BRANCH IF OVF=S=0.
		0259	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0260	BF	AGEB	BRANCH IF S=1.
		0261	ALTB	NOP	CONTINUE HERE IF C <> S
		0262	*		AND Z=0.
		0263	*		
		0264	*(F)	A >= B	
		0265	CI	B	
		0266	BF	9,AGEB	BRANCH IF OVF=S=0.
		0267	BF	12,ALTB	BRANCH IF OVF=Z=0.
		0268	BF	AGEB	BRANCH IF S=1.
		0269	ALTB	NOP	CONTINUE HERE IF C <> S
		0270	*		AND Z=0.
		0271	*		
		0272	*(F)	A >= B	
		0273	CI	B	
		0274	BF	9	

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μ C development



Regardless of its physical condition, a prototype can often benefit from some form of development-system diagnostics. (Photo of System 65 Courtesy Rockwell International)

systems

No two development systems are alike, but no two development tasks are, either. The ideal system remains flexible, satisfying your specific needs.

Edward Teja, Associate Editor

Although nearly every μ C system currently on the market features some development tools, many of these systems are not designed for complex development work. And even if you consider only those systems touted specifically for development tasks, their sheer variety will confuse any attempt at specific point-by-point comparisons.

Clearly, though, a \$500 system does not offer the same capabilities as a \$20,000 one; they don't compete directly. The question, then, is not which development system is the best, but which development tools best suit your task. After ascertaining that requirement, you can then determine which system provides these tools in the most cost-effective package.

Start by defining the development task; realistically assess the minimum and maximum requirements your system must meet. The questions in the nearby **box** can serve as a guide to a first-level evaluation. For example, if your end product's available memory is limited, writing programs in PASCAL would be unrealistic—even though many development systems either now

offer it or will add it during the next year. The requisite interpreter alone resides in approximately 10k of ROM in most PASCAL versions—and that does not include the program size. FORTRAN, to name a second example, compiles nicely, yet its run-time package, whose size varies from compiler to compiler, requires additional memory. In fact, for products with less than 8k of memory, programming in anything higher than assembly language can prove to be a blue-sky proposition.

Evaluating the suppliers

In the beginning, development systems were created for one purpose: to sell silicon. Semiconductor manufacturers realized that the ease of producing software for a processor correlated with the volume of that device's sales. Although these manufacturers still produce development systems to sell their chips, the entry of independent equipment manufacturers into the market has led some semiconductor makers to market their systems as independent-profit-center products. The successful entry of independent firms has made it clear that selling development systems and development tools is profitable in



All the tools for software and hardware development and debug for Z80 and 3870 μ Ps come in Mostek's AID-80F. The enclosure, a CPU with 32k of RAM, two single-sided drives, a card case and cabling cost \$5995 total.



Costing \$14,500, Intel's Intellec Series II Model 230 comprises 64k of RAM; two dual-density floppy-disc drives; a 2000-character CRT and the ISIS-II operating system. (The ICE module for 8086 emulation and the SDK-86 board shown in the photo are not included in this price.)

Independent vendors add features to dedicated systems

and of itself.

The independent equipment manufacturers (companies not engaged in making μ Ps) typically offer universal systems. ("Universal," in this context, means only that a system, rather than being committed to a particular processor, functions as a development station for several processors.) Tektronix, one of the best-known independents, views the market as one for test equipment. Thus, its Model 8002's emulator circuitry and debug capability were developed by logic-analyzer designers.

The 8002's Real-Time Prototype Analyzer option, for example, provides a trace of up to eight locations on a prototype circuit. This sophistication is costly, though: An 8002 with F8, 3870 and 3872 support packages costs \$13,700. The system also supports 6800, 8080A, 8085, Z80 and TMS 9900 μ Ps.

The time lag between the appearance of a new μ P and the availability of development systems that serve it is significant to OEMs. Naturally, the chip's manufacturer will offer first delivery on development support; the availability of support for the chip on universal systems, though, typically awaits mass-market acceptance of the device. Thus, if you can't wait for an indefinite period of time for a software or hardware module that supports the new device on your universal system, you'll either have to write your own cross assembler or buy the appropriate dedicated system from the chip manufacturer.

Independents perform another service beyond broadening the variety of available alternatives—they provide products that make dedicated systems slightly more universal. Proc-



Development tools don't always come in system packages. Applied Microsystems' EZ-80 permits full emulation of Z80 μ Ps while providing built-in diagnostics.



Several users can share a single CPU and mass-storage devices when working on Futuredata's Microsystems. These systems range from \$11,500 to \$69,450, depending on configuration.



An all-in-one configuration, Zilog's ZDS-1 provides emulator, logic analyzer and ROM/RAM-simulator functions.



A general-purpose system designed more for business than development work, Pertec's 8085-based PCC 2000 can nonetheless serve for some development tasks.

essor Innovations, for example, can (for \$1500) utilize the magic of cross assembly to provide Intel development-system users with TMS 9900, SBP 9900 and S9900 development capabilities.

As another alternative, Solid State Scientific Inc proffers a \$500 macro assembler that permits use of Intel's Inteltec system as an SCP1802 development system. In the same manner, cross assemblers can convert any μ C into a development system—EDN did it for the 8086 (EDN, February 5, 1979, pg 115). Incidentally, Intel used cross assemblers and cross compilers (PL/M) to make the 8080-based Inteltec system do development work for the 8086.

Just as adding software increases the versatility of an existing system, a similar approach can compensate for a shortage of specialized development hardware. Intersil, for example, provides its Model 6920 EPROM programmer for use with any system having either an RS-232 or current-loop interface. Thus, for approximately \$1000, virtually any system can program PROMs.

In short, just because a development system is purchased as a dedicated configuration doesn't mean it must stay that way.

Making more than a development system

There's another alternative, though. Many higher priced systems, such as National Semiconductor's Starplex, offer blandishments (such as FORTRAN) unrelated to their systems' use in

the development task. National assumes that many OEMs can't afford to pay \$10,000 or more for "only" a development system and that a system offering full-service computational power covers a broader range of applications. The extra capability isn't free, of course, but bundled into the price of a development system, it becomes less noticeable.

Assume, for example, that your company can afford (or will authorize) only part of the necessary cash for a development system; assume also that some EEs in the firm are using time sharing to solve problems in FORTRAN. If you are willing to share access to the system, all of you can combine budgets to buy one system that does both jobs.

Contrast this approach with the method used by companies such as Futuredata: It believes multiuser development systems are an effective means of reducing development costs. Its Six Station Network, for example, provides facilities for six users simultaneously, including four software-development stations; two hardware-development stations; four double-sided, double-density floppy discs; and a 300-lpm printer. The system accommodates five different user-specified 8-bit processors. Cost per programmer is about \$11,575—not cheap by any standard—but Futuredata feels that each programmer must have a separate console in a realistic development effort. Tools such as symbolic debug

Defining the development task

In order to select a system that will maximize your development effort, you must first define your job in terms of the available development tools. The necessary questions divide into hardware and software categories.

Hardware

1. How many different types of μ Ps must the system be able to accommodate?
2. Will the code to be developed reside in PROM?
3. Is the application hardware sufficiently complex that it would benefit from in-circuit emulation?
4. Will the system be available for uses other than development?
5. How many programmers must have access to the system at any one time?

Software

1. Is the code to be developed sufficiently long (and complex) to require modularized writing? If so, make sure that the assemblers and compilers provided with the development system produce relocatable, linkable code. The former permits modification of its addresses at load time; the latter uses pseudo-ops to maintain communication between separately compiled modules and the main program. For detailed discussions of these features, see "The software wall and what you need to scale it" (EDN, March 5, 1978, pg 75).
2. Can your code be written in a high-level language? A secondary question here should be: What languages do members of your development

team already know? You shouldn't have to spend time learning new languages unnecessarily.

3. Will programmers be using the system to write code for processors other than the resident CPU? If so, can cross assemblers be produced in-house? Are cross assemblers that produce code for the target processor available on the development system?

4. Will some routines be used repeatedly? What hardware/software does the system offer to facilitate building libraries of subroutines?

5. Will the system be shared for other engineering tasks? If yes, you will want FORTRAN or some high-level language for the individuals involved in those tasks. Don't expect BASIC to be adequate.

Extra capability makes dedicated systems generally useful

and interactive editing, hallmarks of this kind of system, make system development this network's primary purpose.

Setting system guidelines

Are there such things, then, as standard system tools? No; they depend on the application. You wouldn't consider hardware emulation necessary if the target product were relatively trivial, yet for complex products, Intel's ICE, National's In-System Emulation or one of the numerous other emulator products can save time and effort—permitting a real-time analysis of code as it executes on your hardware.

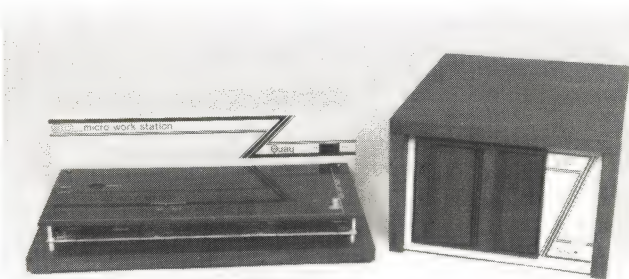
And if the software in your job is trivial, the best solution might not be a development system at all. A stand-alone emulator, such as the EM-6800 or EZ-80 from Applied Microsystems,

provides an alternative for testing hardware prototypes. To emulate a chip, the EM-68 plugs into a 6800 CPU socket. You can take one home for \$1860.

Millennium Systems also uses plug-in modules in its Microsystem Analyzer, supporting 6800, 8080, 8085A-2 and Z80 μ Ps. You can equip this stand-alone emulator, which costs \$2750, with a \$1000 signature-analysis option for time-domain capability.

Although the necessary set of tools is entirely task dependent, though, it *is* possible to outline requirements that apply to any μ C system used in a commercial environment. These general system requirements don't relate specifically to the required set of development tools, but rather to the concept of realistic system hardware and software. Your system's capabilities will be more flexible if the system is chosen according to these guidelines:

- Include at least two floppy-disc drives.



Flexible enough to expand into any application, Quay Corp's Model 90MWS, equipped with 4k of RAM but without floppy discs, starts at \$1050.

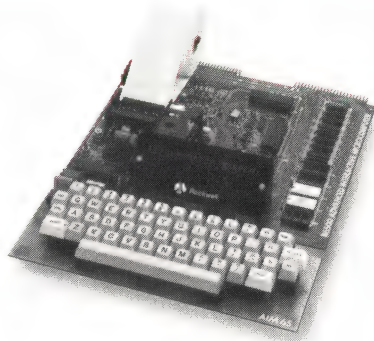


Putting everything in an integrated package, Tano's Outpost features a macro assembler and STRUBAL+ compiler.

From tutor to tool

Rockwell's Aim 65 began as a teaching tool but is currently finding use as a development system. As such, it's one example of the diverse nature of "development systems."

The company wanted to design a portable system that furnished enough tools to illustrate the power of its 6502 processor and peripheral chips. To that end, the Aim 65 board houses a thermal printer, keyboard and alphanumeric display; two 4k ROMs store an advanced monitor. An interface permits adding a cassette, thereby extending the unit's system-software base. The fully equipped board



Not initially intended for use as a development system, Rockwell's Aim 65 has become a fierce competitor in that field.

retails for about \$500—a reasonable price for a teaching machine.

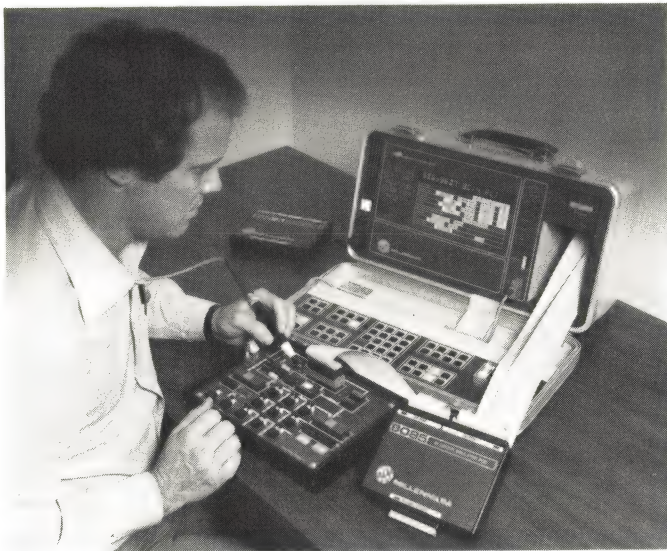
The marketplace had different applications in mind for the unit, though; engineers

began buying it as a development system. Rockwell's management suspects that one reason for this unexpected trend is that the system's price tag suits an engineering department's petty-cash budget, thus keeping accounting and purchasing departments out of the buy decision. After a project can be justified to upper management—with the Aim 65 running the software—the department gets budget approval for a development system.

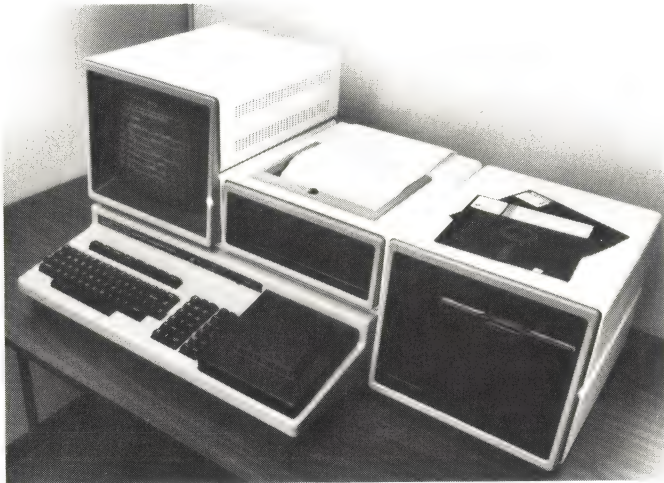
An unrealistic scenario? Perhaps, but the systems are selling to people and companies who already know how a 6502 works.

Regardless of the storage capacity of these drives, it makes sense to use one write-protected disc for a system disc and one for development. Also, disc copying for backup purposes is much easier when you can perform a straight disc-to-disc copy. Why opt for discs at all? Using paper tape can add hours to each stage of the development process; a single edit-and-assemble session can take hours. Furthermore, magnetic tape is limited in speed and capacity, and more importantly, its files are strictly sequential, whereas discs support directories of named files—another factor that reduces development time. In addition, most high-level-language implementations are disc based—for large development tasks, you will want this design and development aid.

- Look for a good text editor. Regardless of



Plug-in modules emulate the 6800, 8080, 8085A-2 and Z80 μ Ps, making Millennium's Microsystem Analyzer a reasonable alternative to a full development system.



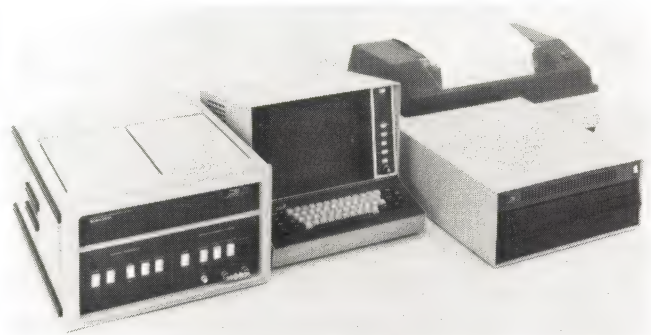
Hoping to capitalize on the Starplex's nondevelopment-system capabilities, National Semiconductor expects the system to find a home with customers who can't afford to buy just a development system.

the type of development your task entails, a large percentage of your time will be spent interfacing with the editor, so ensure that it is powerful and easy to use. Compare many of these editors before committing to one.

- Large jobs require a high-speed printer. Making a top-notch programmer wait for a teletypewriter printout is akin to hiring top-notch hardware designers and making them do their own drafting.
- Make sure that the operating system provides flexible utilities. An impressive array of hardware can be misleading; you must ensure that the operating system will actually transfer data and information to desired locations and devices from designated locations and devices assigned by dynamically alterable utilities. See EDN's Software Design Course (November 20, 1978) for a description of the work you can reasonably expect an operating system to do. Some powerful operating systems are available; the bogus ones will be obvious after you spend a little time comparing systems.



Incorporating complete hardware and software for any 6800-based development task, Motorola's Exorterm 220 costs either \$8600 or \$9200, depending on whether you choose dynamic or static memory.



Designs using bit-slice μ Ps can take advantage of Advanced Micro Computers' System 29, aimed at microprogramming applications (\$18,850).

Consider the human factor

As a final consideration before deciding on a system, spend some time with a demonstrator. Type in some code; do an assembly; print out some listings. Once you purchase the system, it and its quirks become part of your work environment. *Before* you buy is the time to discover that you can't stand the clunk the discs make when the heads load, or that the printer slides across the table as it prints.

Sound a bit like kicking the tires on a used car? Perhaps it is. Perhaps it is also time to recognize that you are more efficient (substitute "cost effective" in reports to management) in a comfortable environment. And efficient production of error-free code, after all, is the sole object of buying a development system.

EDN

Article Interest Quotient (Circle One)
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For more information on development systems, development-system software, stand-alone emulators or general-purpose μ C systems used in development-system applications, contact these manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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Top-octave generators make beautiful music

Add musical sounds to your products with top-octave generators— μ P-controllable chips providing in-tune, multiple-frequency outputs.

Bill Schweber, Instron Corp

If you're designing a product that requires audible signals to inform or attract its user, consider using a top-octave generator (TOG) IC as the tone source. Of course, as an alternative you could always use individually tuned oscillators (perhaps made from 555s), but the TOG offers the following advantages:

- A single IC provides up to 12 simultaneous pitches.
- The pitches are musically related and can be joined into pleasing combinations.
- A TOG contains no critical or drift-sensitive components; thus, its tones are always in tune with each other.
- TOG circuitry is easily expanded to produce almost any number of pitches.
- You can interface a TOG to analog and digital controlling circuitry, including μ Ps.

Top-octave generators divide and conquer

Although a basic understanding of musical pitch helps in applying a TOG (see box) the chip itself is simple and easy to use. A TOG divides a master frequency, usually one well above the audible range, by twelve different integers to produce a complete chromatic octave within the audible range. Because these output frequencies

must be related by an irrational number ($2^{1/12}$) to match the Western equal-tempered scale, no integer divisors can result in perfect pitch accuracy. In fact, the set of twelve divisors itself is not unique, because different master frequencies can be used. TOGs use the divider set tabulated in Fig 1. That set yields an octave with normally inaudible tuning errors and employs the shortest on-chip dividers.

From a practical standpoint, then, only the relative relationships of the pitches, not their absolute accuracy, are critical in determining the "correctness" of the scale as perceived by the ear. In this respect, the TOG excels. Deriving all its pitches from a master oscillator, it produces notes whose relative accuracies depend only on the digital divisors used. The master oscillator need not be especially accurate or stable, unless, for example, you are designing a tuning aid for musical instruments.

Dividers add flexibility to a TOG

A basic TOG circuit (Fig 2) consists of a master oscillator and a TOG chip like the Mostek

NOTE	EQUAL-TEMPERED FREQ AT A4 = 440 Hz	TOG DIVISOR	TOG OUTPUT FREQUENCY	PERCENT ERROR	CENTS ERROR
C	261.63 Hz	478	261.54 Hz	-0.034	-0.58
C \sharp OR D \flat	277.18 Hz	451	277.20 Hz	+0.005	+0.08
D	293.66 Hz	426	293.46 Hz	-0.069	-1.19
D \sharp OR E \flat	311.13 Hz	402	310.98 Hz	-0.046	-0.80
E	329.63 Hz	379	329.85 Hz	+0.069	+1.19
F	349.23 Hz	358	349.20 Hz	-0.007	-0.12
F \sharp OR G \flat	369.99 Hz	338	369.87 Hz	-0.034	-0.59
G	391.99 Hz	319	391.89 Hz	-0.025	-0.44
G \sharp OR A \flat	415.30 Hz	301	415.33 Hz	+0.006	+0.11
A	440.00 Hz	284	440.19 Hz	+0.044	+0.76
A \sharp OR B \flat	466.16 Hz	268	466.47 Hz	+0.066	+1.15
B	493.88 Hz	253	494.13 Hz	+0.050	+0.87

Fig 1—This TOG-output-frequency error table assumes a master-oscillator frequency of 125.015 kHz. The cents-error column has been recalculated and might differ from manufacturers' specifications.

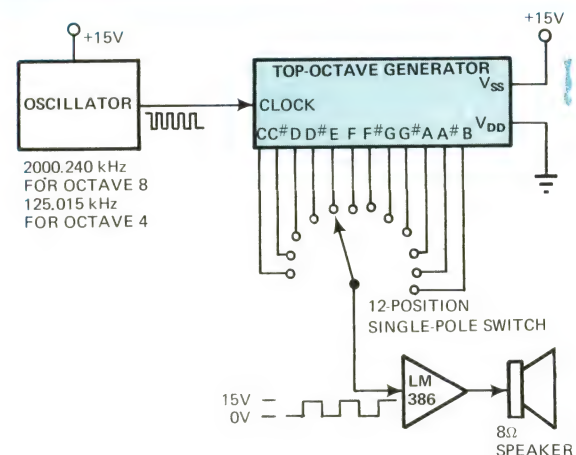


Fig 2—When constructing this basic TOG circuit, choose the master-oscillator frequency according to the desired output-frequency range.

A top-octave generator is never out of tune

MK50240. (As the nearby table shows, AMI, GI, SGS-ATES and National Semiconductor also make TOGs.) The circuit uses a single +15V supply and generates 0 to +15V square waves. All twelve pitches are available simultaneously, making system expansion easy. With the addition of a selector switch, amplifier and speaker, the circuit becomes an electronic tuning fork: To use it, match the pitch of the instrument to be tuned to the TOG note.

You can gain additional flexibility by adding a binary divider between the master oscillator and the TOG; selecting different taps of the divider chain in turn selects different octaves (Fig 3a). However, this circuit only provides one octave span at a time. You can overcome this limitation by connecting dividers to the TOG outputs instead of to the master oscillator (Fig 3b). Each stage of division produces the same note in

descending octaves, thus making the highest octave and all those below it simultaneously available.

Because TOG pitches are square waves, they can be controlled using ordinary CMOS digital gates—there is no need for more expensive analog switches. As shown in Fig 4, a level-shifting transistor implements TTL-level con-

Continued on pg 74

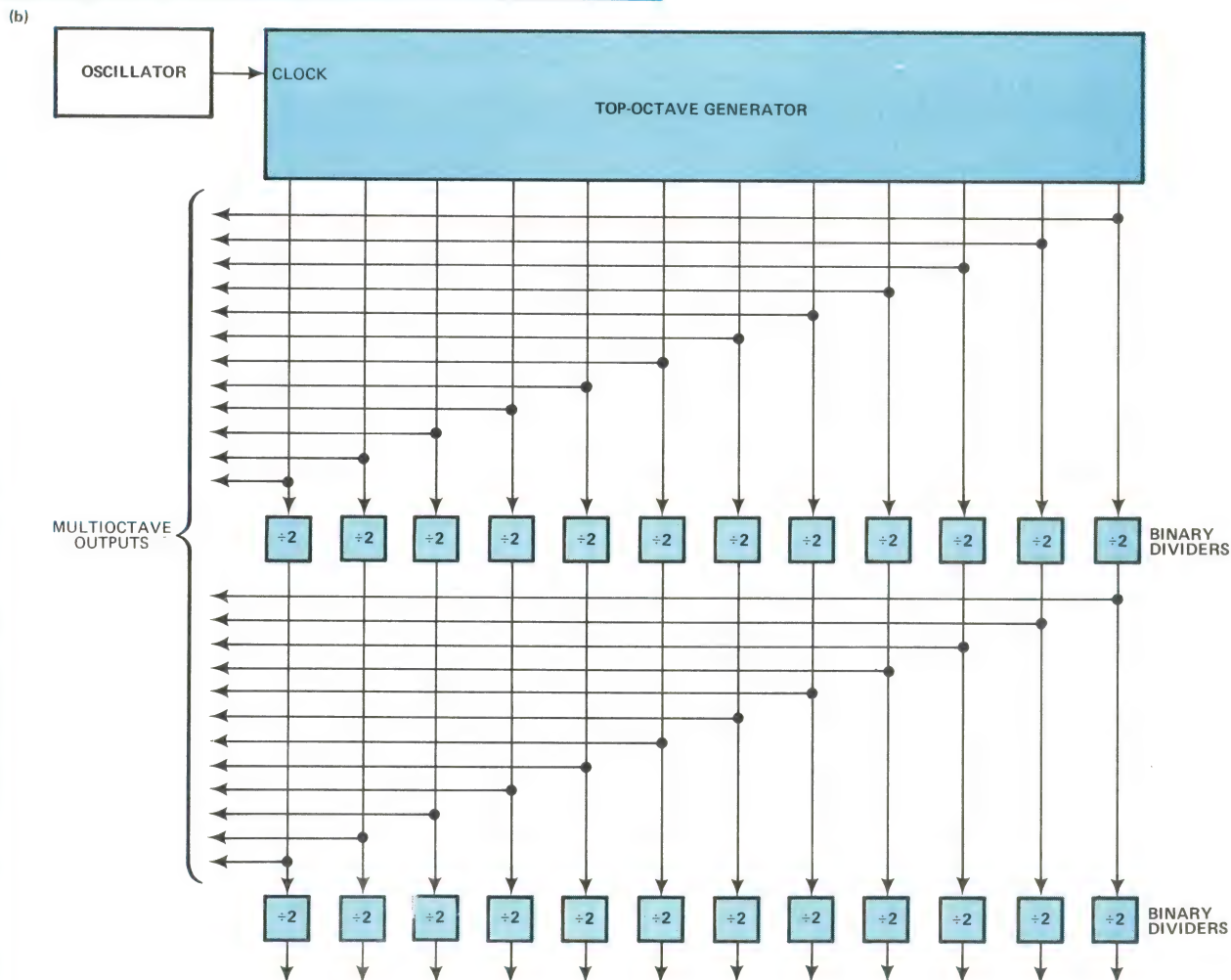
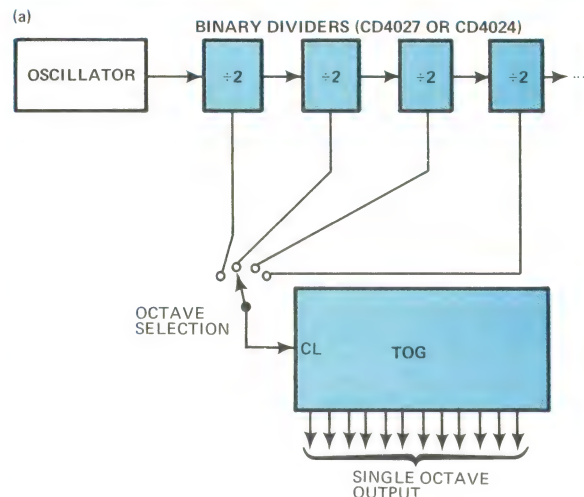


Fig 3—Adding binary dividers between the oscillator and TOG produces octave-switchable outputs (a). Placing the dividers on the TOG outputs makes all notes in all desired octaves available simultaneously (b).

Scales, spectra and common cents

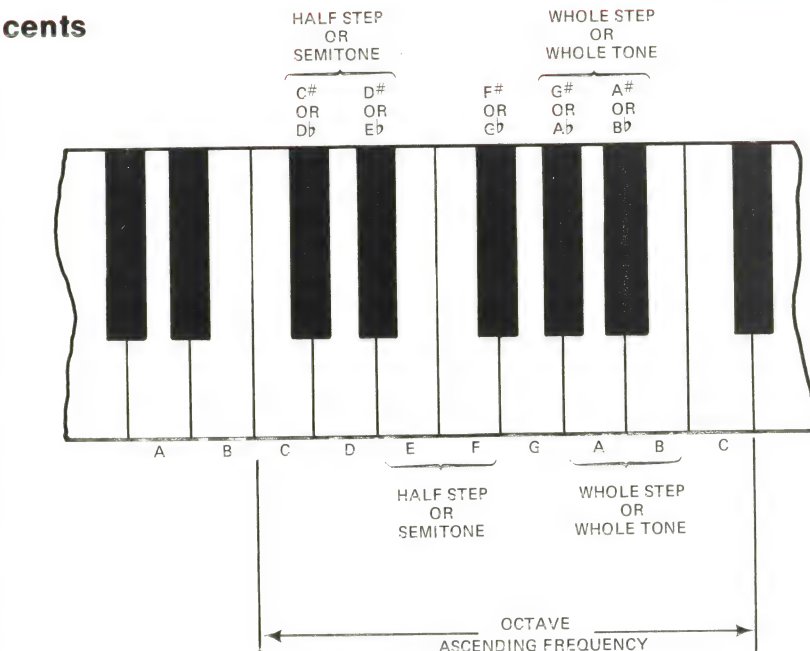
David Ranada, Associate Editor

In Western music, the scale is based on the division of the octave (a 2:1 frequency ratio) into twelve relatively equally spaced pitches (logarithmically speaking). The equal-tempered system of tuning, predominant since the 18th century, has all pitches separated by the same ratio: $2^{1/12}$. With equal temperament, sharpening a note (raising it a half step or semitone; ie, multiplying its frequency by $2^{1/12}$) is musically equivalent to flattening the note above it (dividing that note's frequency by $2^{1/12}$). (Not all systems of tuning, though, retain an audible equivalence between sharpened and flattened notes.) Note that there are "natural" half steps between E and F and between B and C (see figure).

The frequency standard for musical pitches, promulgated only since the period between the two world wars, makes the A above middle C exactly equal 440 Hz; all other pitches can be derived from this standard. A top-octave generator, however, has no inherent pitch; it simply covers one octave. The octave you choose may start and end on any note at any frequency, depending on the master-oscillator frequency. By convention, however, musical octaves begin and end on Cs.

Almost all music concentrates its fundamental frequencies in the two octaves above and below middle C (261.62 Hz); remember this fact if you don't want your design to sound unnatural.

The musical spectrum of a complex tone is called its timbre. Each note produced by a nonelectronic instrument exhibits a characteristic



A section of a piano keyboard illustrates the basic pitch relationship. Pitches separated by a frequency ratio of $2^{1/12}$ constitute a semitone or half step. Two adjacent semitones make up a whole step (with a frequency ratio of $2^{2/12}$). If the leftmost C were the one nearest the center of the keyboard (middle C), the A above it would have a frequency of 440 Hz.

growth and decay of the amplitudes of its harmonics in relation to each other during the note's first few milliseconds. Differences among these initial spectral fluctuations, more than the following steady-state portion of the note, enable listeners to tell musical instruments apart.

Electronic musical instruments generally have very simple initial spectrum fluctuations, if any. TOGs, being digital devices, usually output only square waves, which contain only odd harmonics (TOGs with non-50% duty cycles do contain some even harmonics, however). In contrast, all nonelectronic instruments generate some even harmonics. Thus, the lack of initial spectral fluctuations and of even harmonics makes imitating an instrument by processing TOG square waves extremely difficult.

To the piano tuner—and the tuner-machine maker—accuracy in tuning is measured in "cents." In this case,

a cent divides a semitone into 100 logarithmically spaced increments. A deviation of ± 3 cents from the correct pitch is considered barely tolerable; the best tuning machines should have errors below ± 1 cent. You can determine how far off a frequency is in cents by using the equation

$$\text{Deviation (in cents)} = (1200 / \log_2(\log(\text{frequency ratio}))).$$

A check of many of the TOGs' data sheets reveals that the published error specs are too low; keep this fact in mind. Also, when designing a piano-tuning instrument, include a provision for varying the master-oscillator frequency. All piano strings generate harmonics shifted in varying degrees from their "true" frequencies by the nonideal nature of the strings. Piano technicians compensate for this shift by tuning the harmonics and not the fundamentals. A piano that sounds "in tune" thus has deliberately mistuned fundamental frequencies.

Gain flexibility by adding binary dividers to a TOG

trol. Command signals can come from a μ P port or other digital device. With μ P control, the software merely *controls* the tone by enabling and disabling it. This method of μ P control contrasts with conventional μ P tone production, where the μ P actually *generates* the tones by toggling an output bit at the note frequency, using software timing loops or software/hardware timers and interrupts. Processor control of a TOG considerably reduces software overhead, especially if you desire simultaneous notes.

For chimes and annunciators, hardware sequencers can activate the tones in the required sequences and durations. One sequencing method uses a counter and PROM (Fig 5). Here, the counter steps slowly through the addresses of the PROM, whose output data bits then control the tones; different TOG tones are enabled each time the data lines change.

Obviously, PROM width (in bits) determines the number of tones that can be controlled simultaneously, while PROM length (in number of addresses) affects the complete sequence duration. Even a small PROM, though, can generate reasonably long tone sequences, because you can trade off sequence length against tone duration. A 2-Hz clock driving a 32-word PROM, for example, produces a 16-sec sequence with notes 0.5 sec in duration. And a 512-word PROM driven by a 10-Hz clock generates a sequence 8 min and 32 sec long, yet notes remain

controlled to 0.1 sec.

Because TOG square waves contain many odd harmonics, they might sound too "buzzy" for some applications. Filtering the outputs, however, makes a tone's timbre more natural sounding. If you are using only one octave, filtering is straightforward: A simple RC low-pass filter with a -3-dB point about an octave above the highest pitch suffices. Too much filtering, on the other hand, turns the square waves into sine waves, which sound very dull and lack crispness to the ear.

If your application requires more than two or three octaves, it's best to have a filter for each one. A single filter either cuts off too many of the higher frequencies' harmonics or allows too many of the lower frequencies harmonics to pass. Keep in mind that a piano's fundamental frequencies span a 27.5- to 4186-Hz range—7-1/2 octaves. Don't worry about phase shift in the filters; the human ear and brain are relatively insensitive (under many circumstances) to such shifts.

Simulating the sound spectrum (timbre) of a particular instrument presents a much more

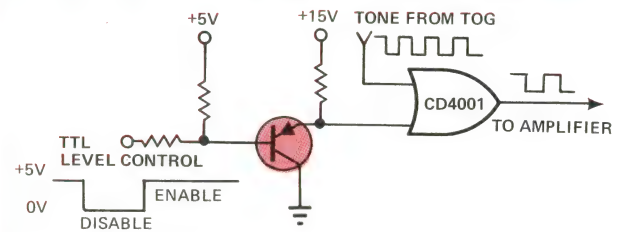


Fig 4—A level-shifting transistor implements TTL-level control over the CMOS gate that enables and disables the TOG tone.

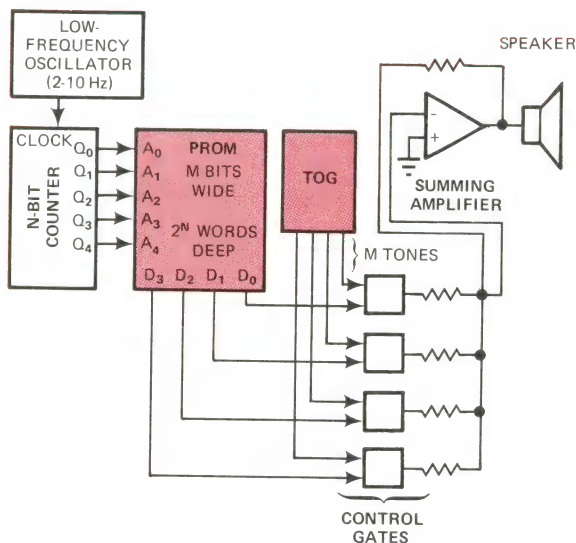


Fig 5—In a tone sequencer, the PROM is cycled through its addresses, and its output bits control the TOG outputs. The PROM can generate any sequence and combination of tones.

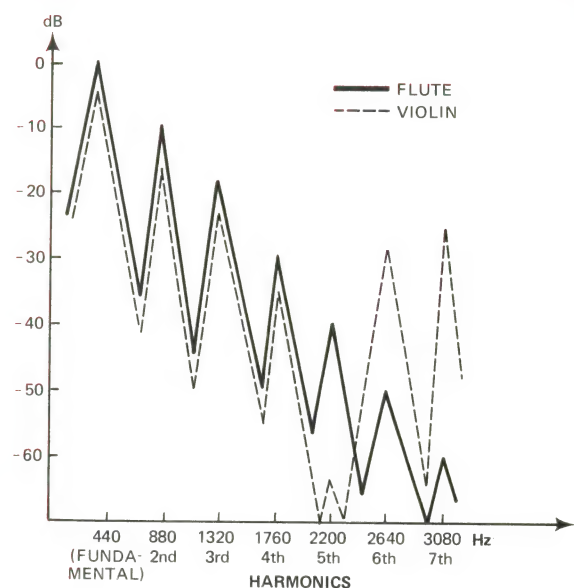


Fig 6—The differing harmonics of the same fundamental tone (440 Hz) for a flute and a violin illustrate the difficulty involved in filtering TOG output to simulate a specific instrument.

[Faint, illegible handwritten notes]

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Model	Voltage/Current Rating Chart		Model	Voltage/Current Rating Chart		Model	Voltage/Current Rating Chart		Model	Voltage/Current Rating Chart		Model	Voltage/Current Rating Chart	
EMA-5/6A	5V @ 1.2A 6V @ 1.0A		EMA-5/6B	5V @ 3.0A 6V @ 2.5A		EMA-5/6C	5V @ 6.0A 6V @ 5.0A		EMA-5/6CC	5V @ 11.0A 6V @ 10.0A		EMA-5/6D	5V @ 15.0A 6V @ 12.5A	
EMA-9/10A	9V @ .75A 10V @ .75A		EMA-9/10B	9V @ 1.8A 10V @ 1.8A		EMA-9/10C	9V @ 3.8A 10V @ 3.6A		EMA-9/10CC	9V @ 8.0A 10V @ 7.5A		EMA-9/10D	9V @ 10.5A 10V @ 10.0A	
EMA-12/15A	12V @ 0.5A 15V @ 0.5A		EMA-12/15B	12V @ 1.5A 15V @ 1.3A		EMA-12/15C	12V @ 3.0A 15V @ 2.8A		EMA-12/15CC	12V @ 6.0A 15V @ 5.0A		EMA-12/15D	12V @ 8.8A 15V @ 8.0A	
EMA-18/20A	18V @ 0.4A 20V @ 0.4A		EMA-18/24B	18V @ 1.2A 20V @ 1.0A		EMA-18/20C	18V @ 2.5A 20V @ 2.3A		EMA-18/24CC	18V @ 4.5A 20V @ 4.0A		EMA-18/24D	18V @ 7.1A 20V @ 7.0A	
EMA-24A	24V @ 0.4A			24V @ 1.0A		EMA-24C	24V @ 2.3A			24V @ 3.8A			24V @ 6.5A	

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Model	Voltage/Current Rating Chart	Model	Voltage/Current Rating Chart	Model	Voltage/Current Rating Chart	Model	Voltage/Current Rating Chart
ETA-12/15C	12V-1.5A 12V-1.5A or 15V-1.3A or 15V-1.3A	ETA-12/15B	12V-0.5A 12V-0.5A or 15V-0.5A or 15V-0.5A	ETA-12/15D	12V-3.0A 12V-3.0A or 15V-2.8A or 15V-2.8A	ETR-122E	5V,6A + 12V,1.5A — 12V,1.5A or 6V,5.5A or + 15V,1.3A or — 15V,1.3A
ETA-5C	5V-3.0A 5V-3.0A or 6V-2.5A or 6V-2.5A	ETA-5B	5V-1.2A 5V-1.2A or 6V-1.0A or 6V-1.0A	ETA-5D	5V-6.0A 5V-6.0A or 6V-5.0A or 6V-5.0A	ETR-142E	5V,6A 12V,1.5A or 6V,5A or 9V,1.2A or 15V,1.3A or 5V,0.8A
ETA-515C	5V-3.0A 15V-1.3A or 6V-2.5A or 12V-1.5A	ETA-515B	5V-1.2A 15V-0.5A or 6V-1.0A or 12V-0.5A	ETA-515D	5V-6.0A 15V-2.8A or 6V-5.0A or 12V-3.0A	ETR-113E	5V,6A 5V,3A 18V,1.0A or 6V,5A or 6V,2.5A or 20V,1.0A or 24V,1.0A
ETA-524C	5V-3.0A 24V-1.0A or 6V-2.5A	ETA-524B	5V-1.2A 24V-0.4A or 6V-1.0A	ETA-524D	5V-6.0A 24V-2.3A or 6V-5.0A	ETR-132E	5V,6A 18V,1.0A or 6V,5A or 20V,1.0A or 15V,1.3A or 24V,1A

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Functions*	6	6	6	5
Ranges	34	34	21	21
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VENDOR	IC NO	INPUT FREQ RANGE (kHz)	NUMBER OF OUTPUTS	OUTPUT DUTY CYCLE	MAXIMUM SPECIFIED ERROR (CENTS)	POWER SUPPLIES (V)	POWER (mW)	NOTES
NATIONAL SEMICONDUCTOR	MM5555	7-2200	7	30%	0.51	-27, -14, -10	650	G TO C
	MM5556	7-2200	6	30%	0.51	-27, -14, -10	650	C# TO F#
	MM5832	7-2100	7	30%	1.16	-27, -14, -10	585	G TO C
	MM5833	7-2100	6	30%	1.16	-27, -14, -10	585	C# TO F#
	MM5891AA	100-2500	13	50%	1.16	-11 TO -16	560	5891AB WITH 30% DUTY CYCLE
GENERAL INSTRUMENT	AY-1-0212	250-1500	12	50%	1.16	-12 TO -16, -23 TO -28	750	HIGH ACCURACY
	AY-1-0212A	250-2500	12	50%	1.16	-12 TO -16, -23 TO -28	750	
	AY-3-0214	100-4500	12	50%	0.5	+10 TO +16	1.9W	
	AY-3-0215	100-4500	13	50%	1.16	+10 TO +16	1.9W	
	AY-3-0216	100-4500	13	30%	1.16	+10 TO +16	1.9W	
MOSTEK	MK50240	100-2500	13	50%	1.16	-11 TO -16	600	
	MK50241	100-2500	13	30%	1.16	-11 TO -16	600	
	MK50242	100-2500	12	50%	1.16	-11 TO -16	600	
AMI	550240	100-2500	13	50%	1.16	-11 TO -16	600	
	550241	100-2500	13	30%	1.16	-11 TO -16	600	
	550242	100-2500	12	50%	1.16	-11 TO -16	600	
	550243	100-800	13	50%	1.16	-11 TO -16	600	
	550244	100-800	13	30%	1.16	-11 TO -16	600	
	550245	100-800	12	50%	1.16	-11 TO -16	600	
SGS-ATES	M 087	15-2500	12	NA	1.16	-5, +5, -12	400	

The specifications on these TOGs come from their manufacturers' data sheets.

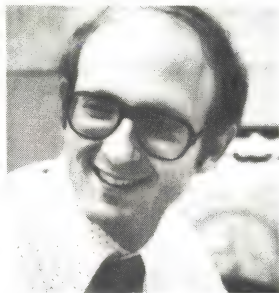
difficult challenge. Because of the different amplitudes of its harmonics, a flute note sounds very different from the same pitch on a violin (Fig 6). Note that for the flute, each harmonic's amplitude decreases about 10 dB from the

preceding one. For the violin, the fifth harmonic is negligible, but the sixth and seventh harmonics are louder than the fourth. Piano spectra, incidentally, are extremely complex and difficult to recreate electronically.

EDN

Author's biography

Bill Schweber, an engineer with Instron Corp, Canton, MA, designs μ P-based controls for materials-testing equipment. He received a BS degree from Columbia University and an MS from the University of Massachusetts. Bill's hobbies include bicycling, photography and model railroading.



Article Interest Quotient (Circle One)

High 473 Medium 474 Low 475

Manufacturers of top-octave-generator ICs

For more information on top-octave generators and other music-related circuits, contact these manufacturers directly or circle the appropriate number on the Information Retrieval Service card.

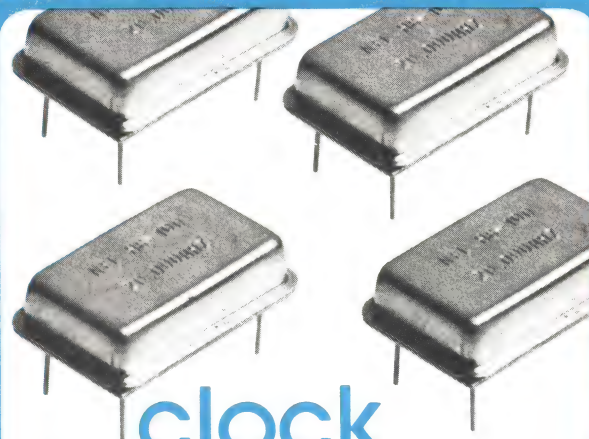
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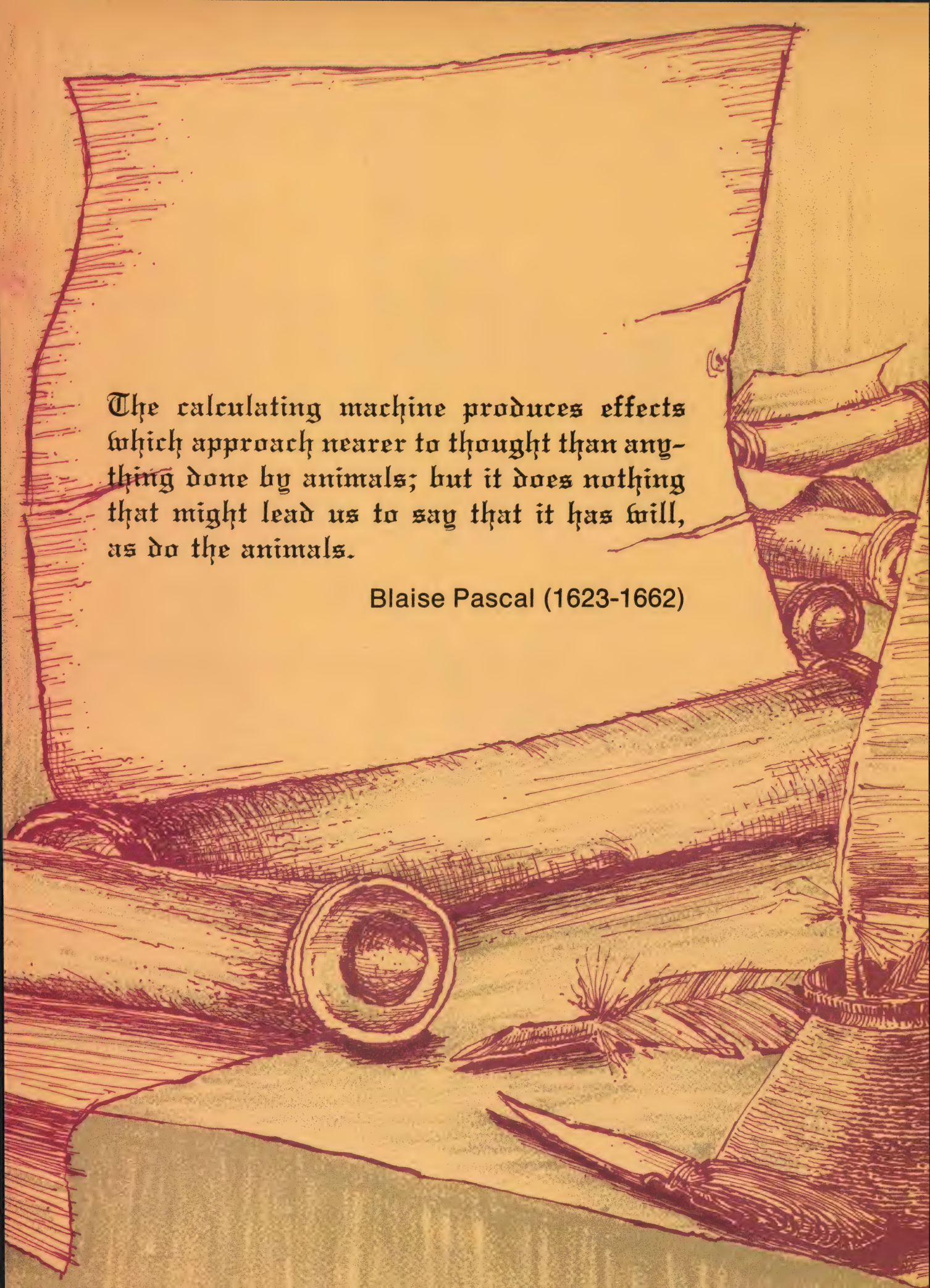
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A detailed illustration in a reddish-brown ink style. It features a large, unrolled scroll that dominates the lower half of the image. The scroll has a textured, fibrous appearance. To the right of the scroll, a quill pen lies horizontally. The quill has a long, straight shaft and a small, dark, feathery tip. The background is a light, textured surface, possibly a piece of parchment or paper. The overall style is reminiscent of a woodcut or a detailed pen-and-ink drawing.

The calculating machine produces effects
which approach nearer to thought than any-
thing done by animals; but it does nothing
that might lead us to say that it has will,
as do the animals.

Blaise Pascal (1623-1662)

PASCAL

With origins in the academic world, PASCAL has now become the darling of commercial computer makers and users. Why this enthusiasm? And what can the language do for you?

Jack Hemenway and Edward Teja,
Associate Editors

In the rush to be the first into print with statements and comments about a new language, the obvious facts—what the language offers and what its disadvantages are—often get lost in the shuffle. Here we tune into a description of what PASCAL is, how it is implemented (including the differences of opinion among implementers) and what it offers to programmers.

Pascal wasn't a programmer

Niklaus Wirth drafted the first version of PASCAL in 1968; he designed it as a teaching tool and incorporated into it the valuable features of older languages. PASCAL grew out of the ALGOL family of languages and thus has proved easy to learn, highly readable and easy to compile. Today nearly every manufacturer of computers is either currently selling or promising future availability of a version of the language on its machines.

It's important to stress the words "a version," because there is no one "Version," or even a PASCAL standard. Despite the numerous descriptions extant, PASCAL is not yet officially defined.

In order of popularity, there are three possible standards. Industrial μ C users and makers tend to favor the version being sold by the University of California at San Diego (UCSD)—largely because of its \$200 price. Both the IEEE PASCAL Standards Committee and the ANSI X3J9 technical committee are considering a document presented to them by the International Standards Organization (ISO)—a document originated by a working group within the British Standards Institution (BSI) and spearheaded by A M Addyman of the University of Manchester. The third standard is simply a referral back to the Wirth book—all proposed versions seem to claim this historical link to some extent.

Nor is this the end of the confusion. UCSD endorses the BSI document as a definition of the basic language, yet not as a complete standard. The PASCAL User's Group (headquartered at the University of Minnesota) is pushing hard to have the BSI document adopted as it stands. And certain corporate representatives present at the recent ANSI meeting expressed serious reservations about letting "academics" such as Wirth and UCSD's Kenneth Bowles play any significant role in the serious matter of defining a commercial-language standard.

Making the world structured

The catch phrase for PASCAL is structured programming—in the sense of block structure in the style of ALGOL. The concept refers to the process of declaring identifiers inside a procedure or function that have no meaning outside that subprogram. Alternatively, identifiers declared outside a subprogram can generally be used inside it. The specific set of rules governing this process constitutes PASCAL's scope rules.

The PASCAL format thus supports

The PASCAL mania

Everywhere you look today, it seems as though there is another article on PASCAL; the interest in the language appears intense enough to classify it as a fad. Posters of Blaise Pascal decorate booths at computer shows; books by Niklaus Wirth and Kathleen Jensen, and more recently by Dr Kenneth Bowles of the University of California at San Diego, turn out to be their publishers' best-selling textbooks; Dr Bowles finds himself facing 350 students in this semester's PASCAL course.

In short, a language written to teach programmers how to program has become the rage outside academia. This Special Report helps resolve the resulting trauma and confusion.

Interpretive versions of PASCAL don't usually support interrupts

a responsive chord in the marketplace.)

Manufacturers find the PASCAL Microengine technique practical in one important respect—the PASCAL it implements is UCSD's; if the industry standardizes on another version, all Western Digital must do is alter the microcode to accommodate that version. An additional benefit arises directly from UCSD's incarnation of the language—the software package that provides the interpreter also furnishes a complete operating system, an editor and BASIC capability.

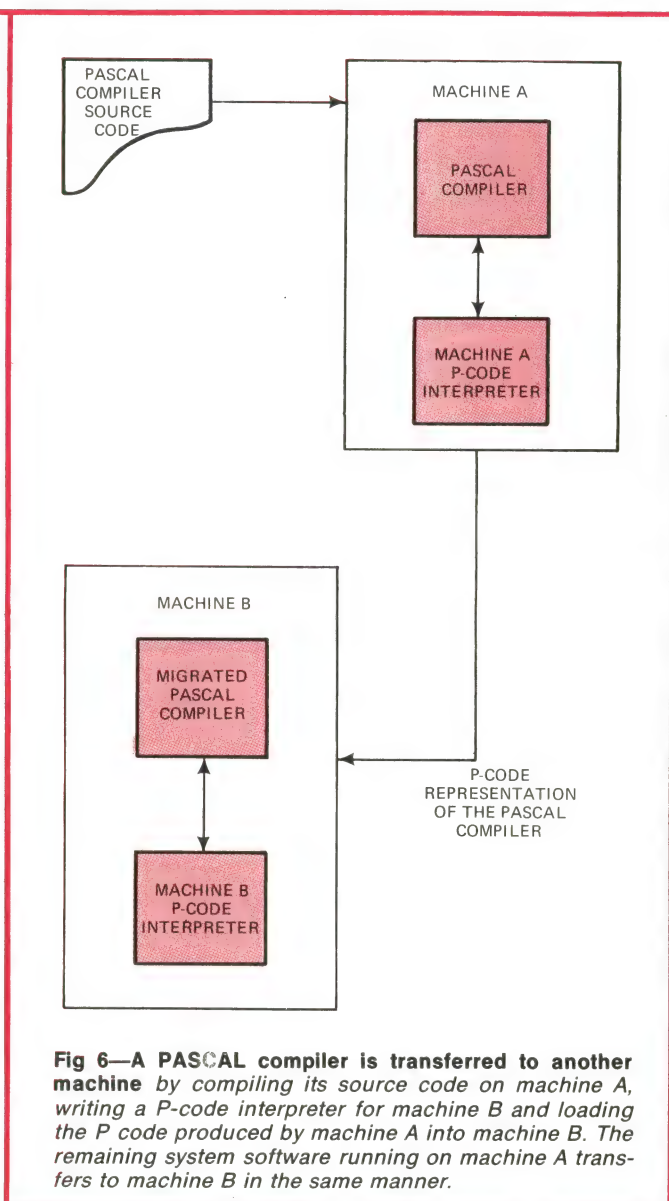
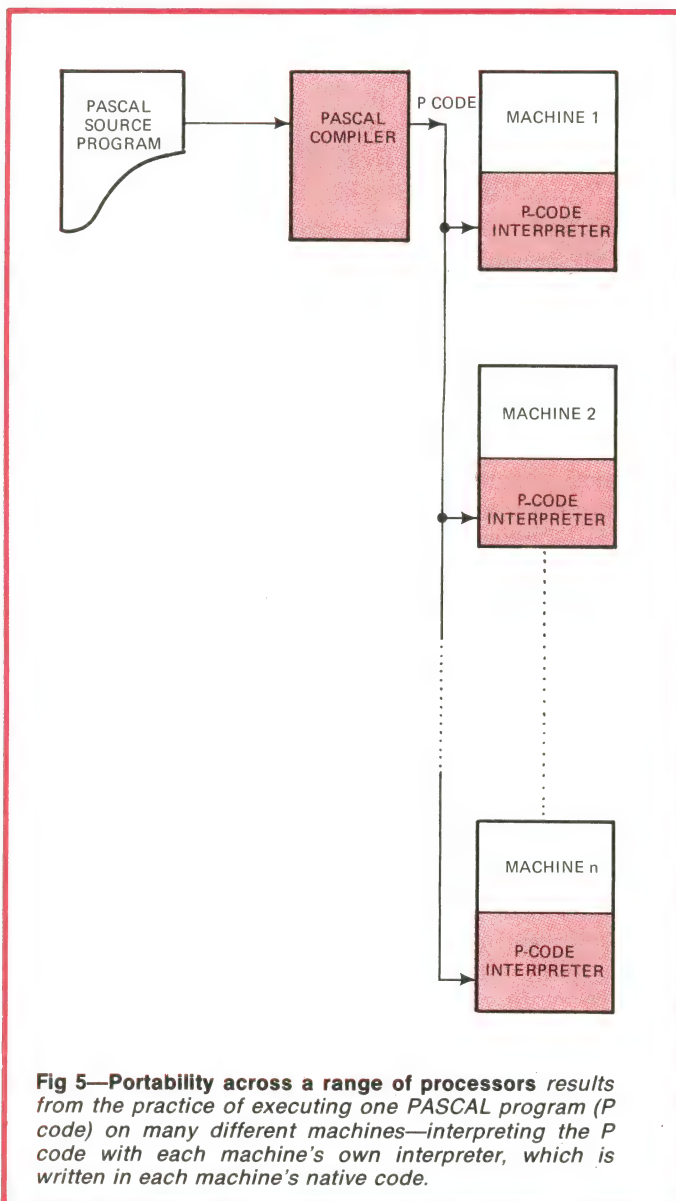
PASCAL versus disc systems

Lack of I/O capability represents PASCAL's major drawback. Because business-oriented I/O is given short shrift in computer-science classrooms, it accordingly receives similar treatment

in the Jensen/Wirth draft. The emphasis in an "ideal" classroom language centers on teaching algorithms, rather than relating a program to its environment (peripherals). Thus, the language places little emphasis on random and indexed-sequential (ISAM) files—these are of serious concern to the commercial programmer and anyone with hopes of competing in a commercial setting.

On the other hand, available PASCAL compilers have given rise to controversy merely because they *attempt* to provide customers with a state-of-the-art I/O package; some PASCAL boosters shriek at any deviance from Jensen and Wirth.

However, the fact remains that Jensen and Wirth did not define adequate I/O capabilities for business applications, and adherents who wish to create a PASCAL standard must thus deal with a complete overhaul of the language's I/O package—which could mean creating extensions. UCSD's version, for example, furnishes both the



Jensen/Wirth tape-I/O capability and extensions to provide disc I/O; the operating system assumes that I/O is disc-based unless the operator specifies otherwise. According to UCSD's Dr Bowles, this procedure, although it accommodates the commercial user's day-to-day applications, is frowned upon by language purists.

In any event, the question of I/O must be resolved before use of the language makes any sense in a real-world computer system. When you're evaluating various PASCAL compilers, this capability (or the lack of it) can be a good starting point.

PASCAL escalation escalates

And so PASCAL expands its influence. This year alone, Apple Computer, Cromemco and Heath, to name a few firms, will add UCSD PASCAL to their offerings. Responding to market pressure, Intel intends to produce a PASCAL compiler for the 8086, although the firm is also maintaining a definite commitment to PL/M. Furthermore, rumor has it that a UCSD-based compiler will appear on Intel's Intellec system, running under ISIS. Finally, National Semiconductor talks of making PASCAL an in-house standard. In many companies, it already is—standard version or no.

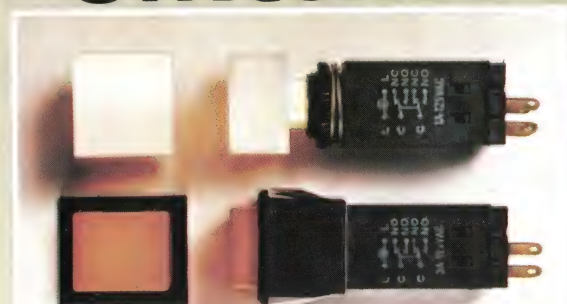
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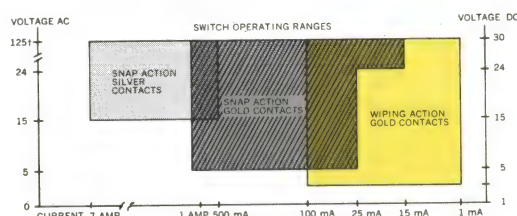
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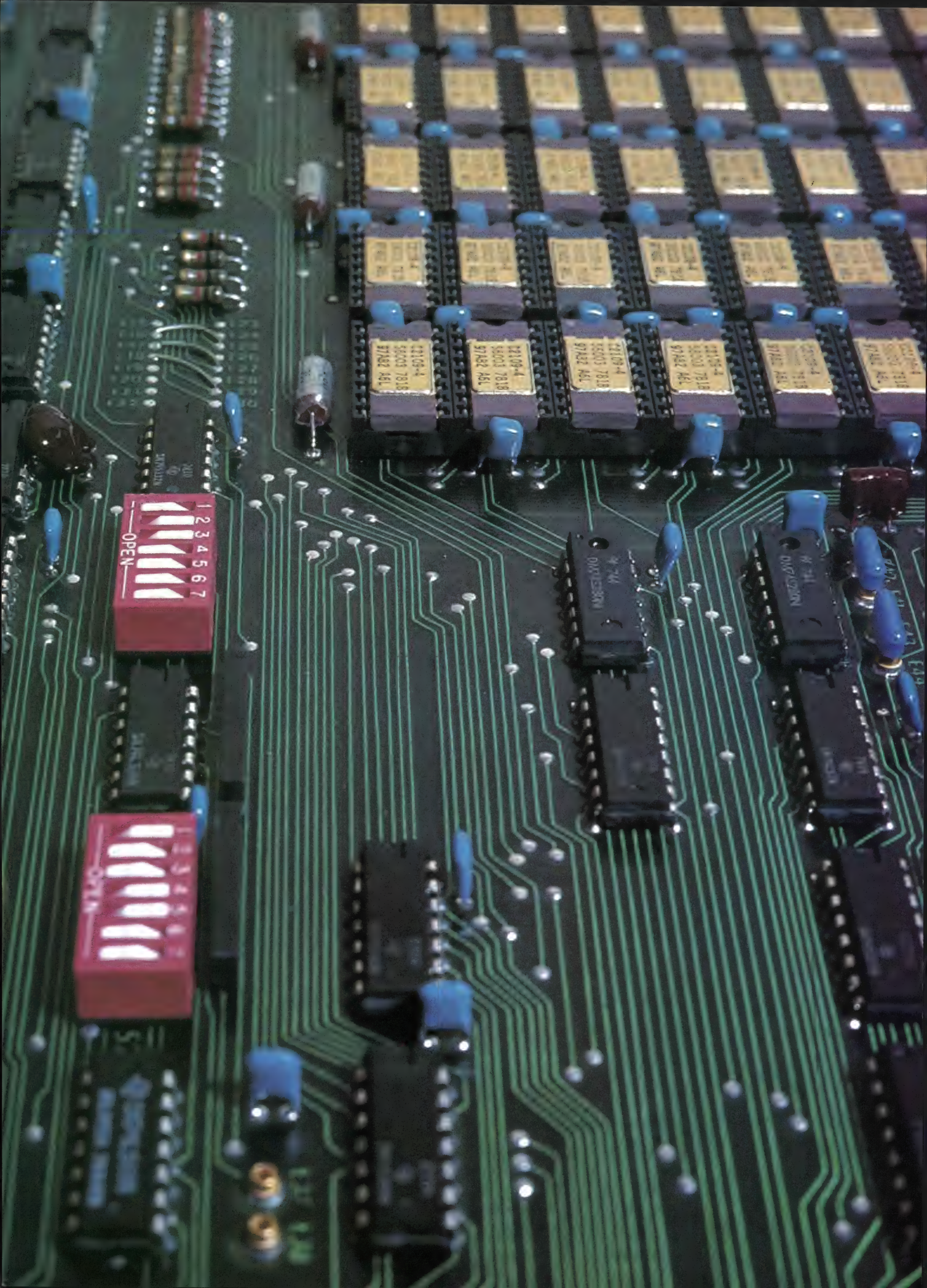
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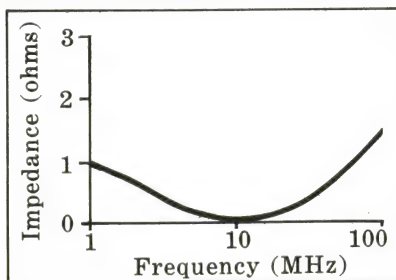
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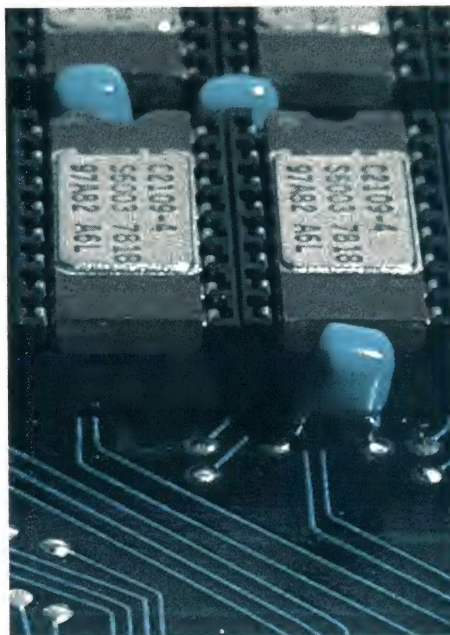
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Measure switcher efficiency without a wattmeter

Although switching power supplies draw pulsed ac currents, you don't need a wattmeter to measure their efficiency. But use of that instrument does yield the most accurate results.

Jeff Wolking, Hewlett-Packard Co

With a dual-trace oscilloscope and a programmable calculator, you can measure the efficiency of a switching power supply to within 8% of the more accurate value obtainable with a wattmeter. And if you're willing to sacrifice even more accuracy for greater convenience, use of a dual-trace scope alone yields results between +5% and -20% of the wattmeter's reading.

The ability to measure power-supply efficiency—and thus optimize it—grows more important as electric utility rates increase. But the measurement task isn't necessarily easy, particularly for switchers. A look at the basics of switching-supply operation reveals why.

Understanding power and efficiency

Power-supply efficiency equals dc output power divided by ac average input power. The latter quantity, in turn, is the time average of the product of instantaneous voltage and current:

$$P_{AVG} = \frac{1}{T} \int_0^T v(t)i(t)dt. \quad (1)$$

Here T is the voltage (or current) waveform period, and $v(t)$ and $i(t)$ are the instantaneous voltage and current magnitudes, respectively. You'll sometimes see average power termed "active" or "real" power.

Another way to calculate average power is to use

$$P_{AVG} = V_{rms} \times I_{rms} \times F_p \quad (2)$$

where V_{rms} and I_{rms} are the root-mean-square values of voltage and current, and F_p is the power factor. For sinusoidal voltage and current,

F_p is the cosine of the phase angle between the voltage and current waveforms. The quantity $V_{rms} \times I_{rms}$ is sometimes termed "apparent" power. Unfortunately, though, because switching supplies draw nonsinusoidal input currents, the concept of a simple phase angle is inappropriate.

For the conventional switching regulator diagrammed in Fig 1, the ideal input current (Fig 1b) instantaneously rises to its maximum value, then decreases cosinusoidally. RFI filters (not shown) and power-line impedance modify this idealization; the actual waveforms appear as in Fig 1c.

In a switcher incorporating preregulation (Fig 2), the preregulator triac maintains relatively constant voltage across the energy-storage capacitor. This technique simplifies the design of the main regulating control loop but can increase overall power-supply cost. The input current for such a preregulated supply is a combination of sinusoidal and ramp functions.

Measuring efficiency two ways

Fig 3 illustrates the easiest and most accurate way to determine a power supply's efficiency: Measure dc output current and voltage with a DVM, then measure ac input power directly with a wattmeter and calculate the necessary ratio. Conventional electrodynamic wattmeters work well in this application, although the need for increased accuracy could require instruments more responsive to the low power factors and sharp, nonsinusoidal current pulses associated with switchers. Comparison measurements for this article were made with a Bell HPM-501, which capitalizes on the Hall effect to provide voltage-current multiplication and makes power measurements sufficient to determine efficiency to within $\pm 4\%$.

It's hard to calculate apparent power for a switcher

A second approach permits estimation of ac input power with a dual-trace oscilloscope and a programmable calculator. Arrange the equipment as shown in Fig 4, and simultaneously display current and voltage on the oscilloscope as shown in Fig 5. Then, from the scope traces, you can directly read values for instantaneous volt-

age and current. An HP-67/97 calculator program (Fig 6) then multiplies and time-averages these values (by using Eq 1), producing an estimate of average power. The following list summarizes the approach:

- Enter the program into the calculator.
- Connect the power-supply output to a load of sufficient capacity to operate the supply at the desired output. Realize that efficiency varies with load and line conditions.
- Display both the voltage and current waveforms on the scope. (Use a current shunt,

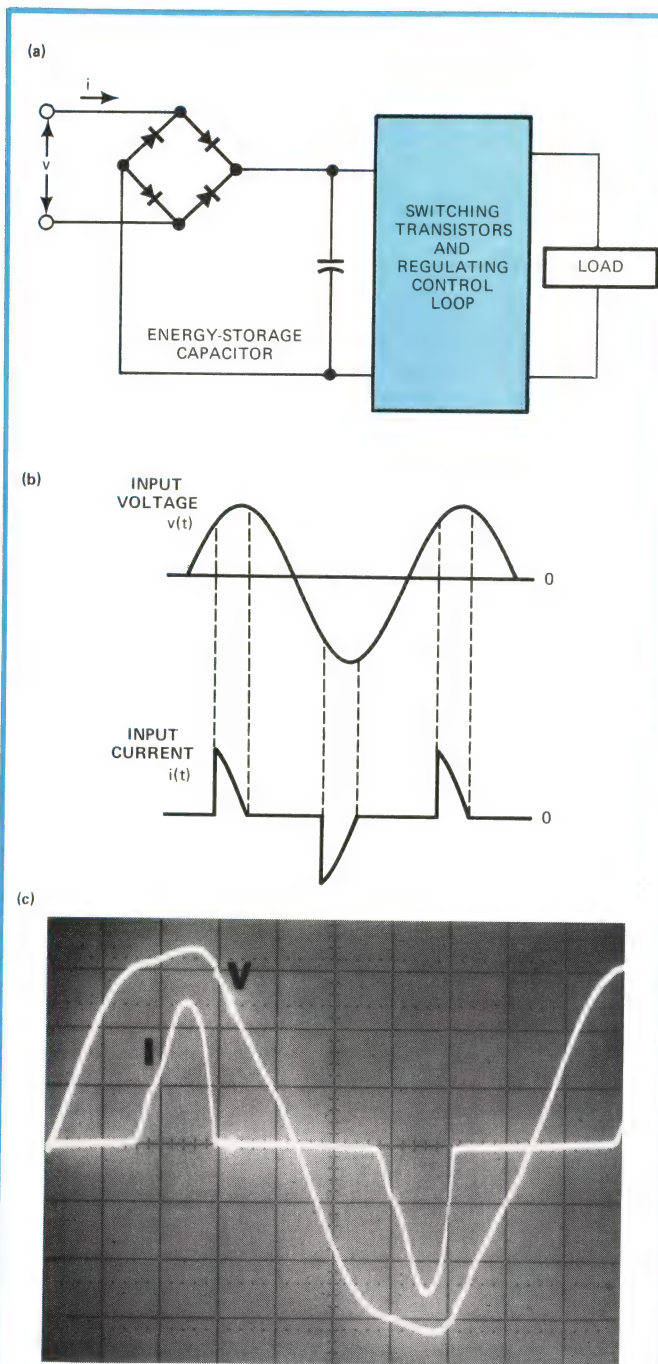


Fig 1—A conventional switching supply (a) draws pulsed ac input currents. The actual current (c) differs from the ideal or expected current (b) because of power-line and RFI-filter impedances not shown in the diagram.

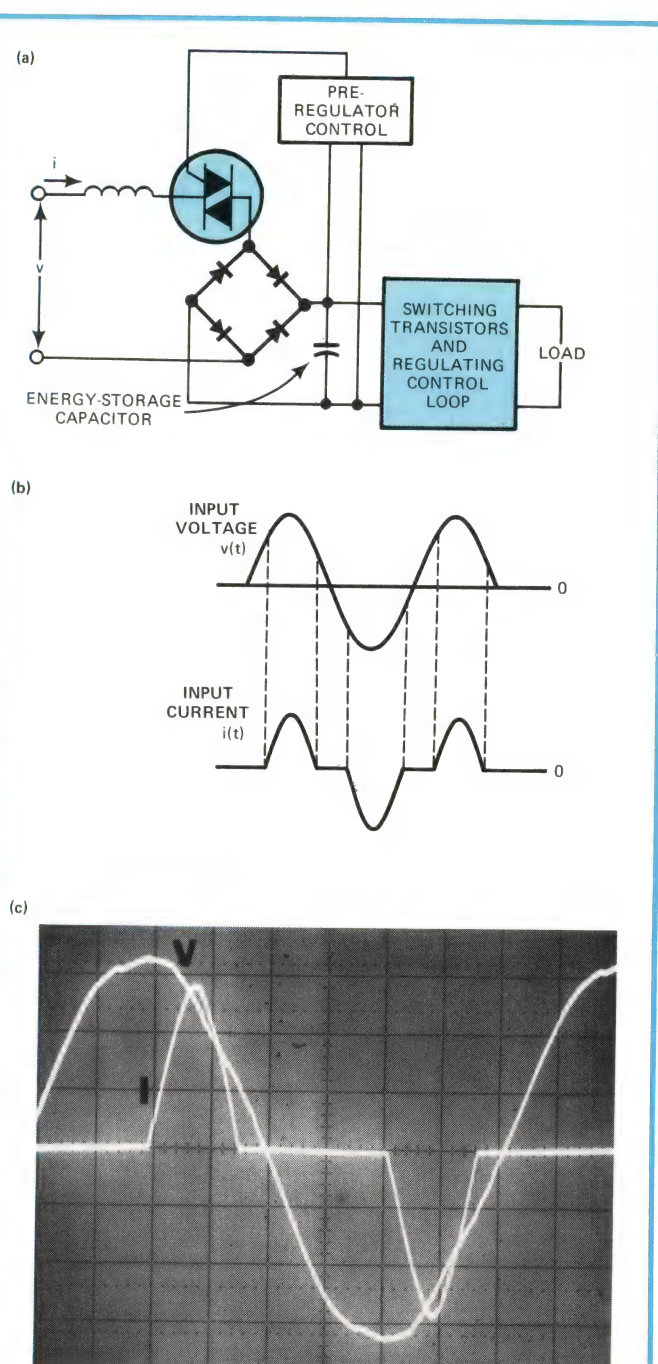


Fig 2—The preregulator triac in a preregulated switcher (a) maintains relatively constant voltage across the energy-storage capacitor. Expected (b) and actual (c) input waveforms differ.

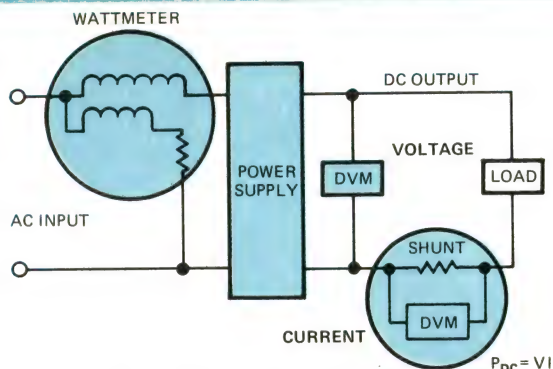


Fig 3—Calculate power-supply efficiency by dividing dc output power by ac input power. You can measure the former quantity with a DVM and the latter with a wattmeter.

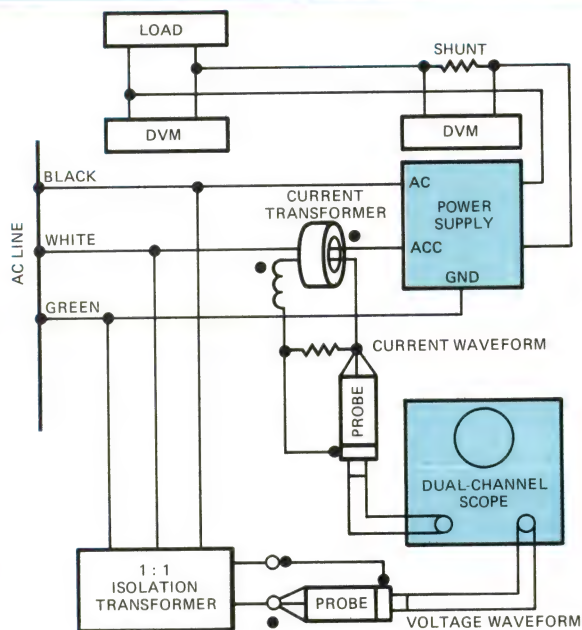


Fig 4—A dual-channel scope forms the basis of a measurement technique that doesn't require a wattmeter.

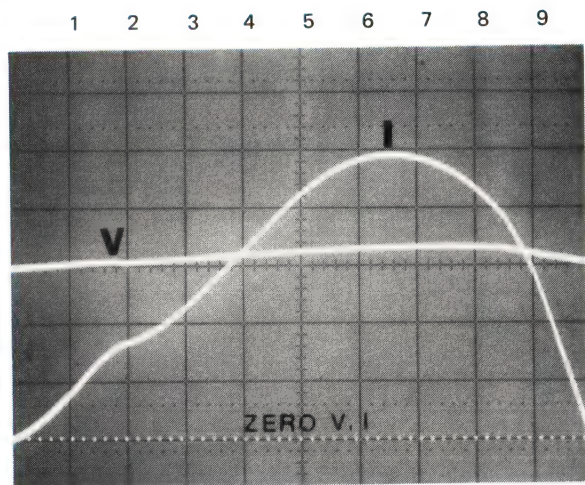
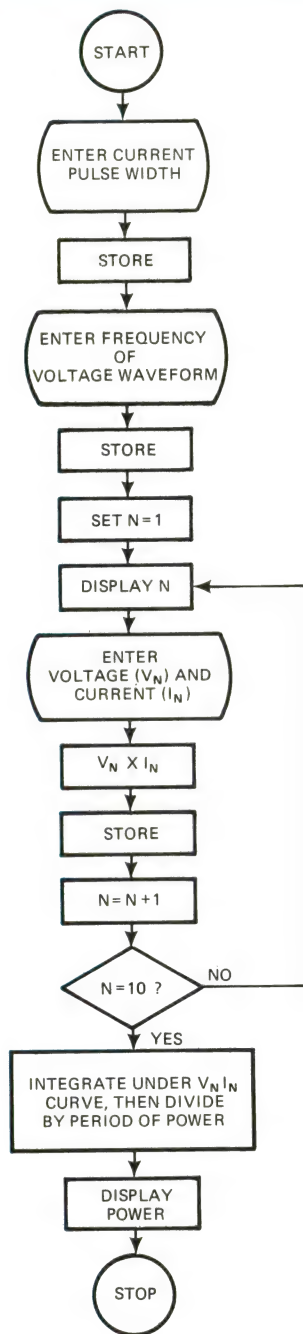


Fig 5—For the oscilloscope + calculator measurement approach, determine corresponding voltages and currents at nine points along their waveforms.

(a)



(b)

001	#LBLA	21 11	026	x	-35
002	CLR6	16 53	027	3	03
003	CF2	16 22 02	028	0	00
004	STOI	35 01	029	+	-24
005	9	05	030	SPC	16-11
006	CHS	-22	031	PRTX	-14
007	X2I	16-41	032	RTN	24
008	RTN	24	033	#LBL6	21 16 12
009	#LBLC	21 13	034	RCL1	36 46
010	x	-35	035	1	01
011	F20	16 23 02	036	0	00
012	GT06	22 16 11	037	+	-55
013	SF2	16 21 02	038	SPC	16-11
014	2	02	039	PRTX	-14
015	x	-35	040	RTN	24
016	#LBL6	21 16 11	041	#LBLB	21 12
017	2	02	042	2	02
018	x	-35	043	x	-35
019	ST+3	35-55 03	044	STO2	35 02
020	ISZ1	16 26 46	045	1	01
021	GT06	22 16 12	046	SPC	16-11
022	RCL3	36 03	047	PRTX	-14
023	RCL1	36 01	048	RTN	24
024	x	-35	049	R/S	51
025	RCL2	36 02			

Fig 6—Enter the voltage and current values obtained via Fig 5's scheme into this HP-67/HP-97 program to obtain average power. For the HP-67, delete steps 30, 31, 38, 39, 46 and 47.

Display voltage and current, then use measured values to get P_{AVG}

- probe, etc, for the current waveform.
- Measure the current pulse's width. Enter this value (in seconds) into the calculator, then press key A.
- Measure the frequency of the voltage waveform. Enter this value (in Hertz) into the calculator, then press key B.
- Expand the waveforms across the scope screen so that the current pulse is exactly 10 div wide (Fig 5). Adjust the waveform amplitudes so you can easily measure them simultaneously.
- Record nine corresponding voltage and current measurements at equal time intervals. Note that each pair of readings corresponds to the intersection of the I and V traces with a major vertical division on the scope screen. (These divisions are labeled 1 to 9 in Fig 5.)
- Enter the voltage and current readings into the calculator as follows (voltage in volts, current in amps):

Item / Press /	Item / Press /	Calculator Displays
Volts ₁ ENTER	amps ₁ C	2
Volts ₂ ENTER	amps ₂ C	3
...continue...		4-9
Volts ₉ ENTER	amps ₉ C	Power (watts).

After you enter the ninth voltage and current pair, the calculator displays the average input power.

To calculate efficiency, measure the dc output power with a DVM, then compute:

$$\text{EFFICIENCY} = \frac{\text{OUTPUT POWER}}{\text{INPUT POWER}} \times 100\%. \quad (3)$$

A third—less accurate—approach

Another technique for estimating ac average input power requires only a dual-trace oscilloscope. A re-examination of Figs 1 and 2 reveals that both the voltage and current waveforms appear approximately sinusoidal when the current is nonzero. You can estimate power, then, by using sine waves to represent both current and voltage (Fig 7). You then calculate average power by averaging the current-voltage product over the voltage's period. This double sine-wave procedure is equivalent to integrating the current-voltage product over only a half cycle of the sine approximation of the current (the current is zero elsewhere), then dividing the result by half the voltage-waveform period.

Let

$$i = I_m \sin\left(\frac{2\pi}{T_p}t\right), \quad 0 < t < T_p \quad (4)$$

and

$$v = V_m \sin\left(\frac{2\pi}{T_v}t + \frac{2\pi\alpha}{T_v}\right) \quad (5)$$

where I_m and V_m are the current and voltage maxima. The quantity $2\pi\alpha/T_v$ is the phase difference between the voltage and current half sine waves (see Fig 7); T_p defines the current pulse width and T_v the voltage-waveform period, both in seconds. Recall that the average-power calculation comes from Eq 1; substituting Eqs 4 and 5 into Eq 1 produces

$$P_{AVG} = \frac{V_m I_m}{T_v/2} \int_0^{T_p} \sin\left(\frac{\pi}{T_p}t\right) \sin\left(\frac{2\pi}{T_v}t + \frac{2\pi\alpha}{T_v}\right) dt. \quad (6)$$

Remember, despite the fact that you average over a time interval of length $T_v/2$, you need only integrate from $t=0$ to $t=T_p$, because i is zero elsewhere.

The integral in Eq 6 is of the form

$$\int \sin(ax) \sin(cx + d) dx = \frac{\sin[(a-c)x - d]}{2(a-c)} - \frac{\sin[(a+c)x + d]}{2(a+c)}, \quad (7)$$

where $a^2 \neq c^2$. Thus,

$$P_{AVG} = V_m I_m \left[\frac{\sin\left[\left(\frac{\pi}{T_p} - \frac{2\pi}{T_v}\right)t - \frac{2\pi\alpha}{T_v}\right]}{\left(\frac{\pi}{T_p} - \frac{2\pi}{T_v}\right)T_v} - \frac{\sin\left[\left(\frac{\pi}{T_p} + \frac{2\pi}{T_v}\right)t + \frac{2\pi\alpha}{T_v}\right]}{\left(\frac{\pi}{T_p} + \frac{2\pi}{T_v}\right)T_v} \right] \Bigg|_{t=0}^{t=T_p} \quad (8)$$

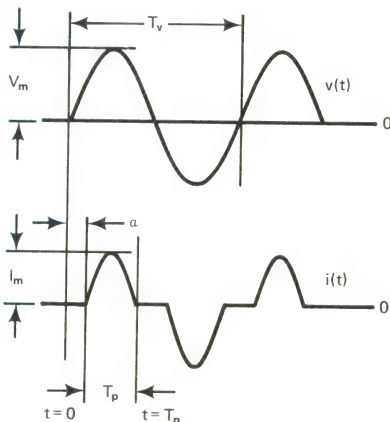


Fig 7—You won't even need a calculator if you approximate the input waveforms as sine waves. Use of Figs 8a and 8b then permits graphical estimation of average power.

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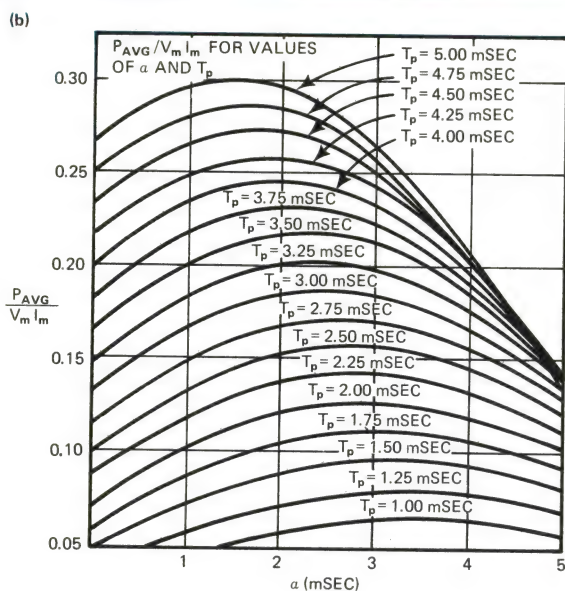
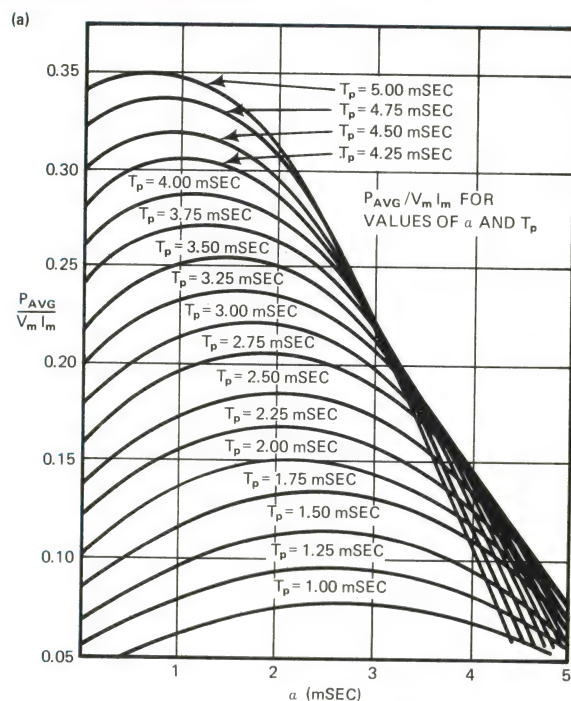


Fig 8—Determine the input waveform parameters V_m , I_m , T_p , α and T_v from Fig 7, then estimate average power directly from these graphs. Graph (a) applies to 60-Hz power-line frequencies; (b), to 50-Hz cases.

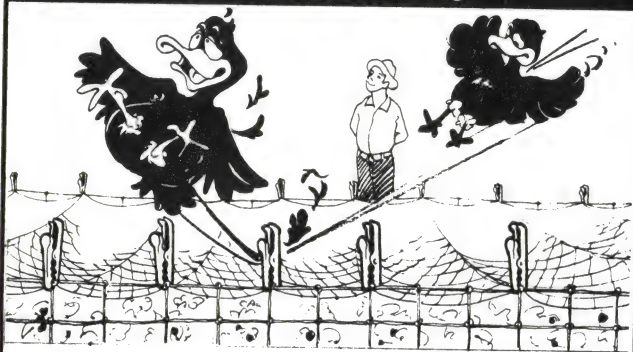
You can measure V_m , I_m , T_p , α and T_v using the equipment setup shown in Fig 4. Find average power directly from Eq 8, or alternatively, find the value $P_{AVG}/V_m I_m$ from either Fig 8a or Fig 8b

and multiply that value by V_m and I_m . (Note that the ratio $P_{AVG}/V_m I_m$ on the vertical axes of Figs 8a and 8b is not the power factor (Eq 2) because V_m and I_m are peak, not rms, values.) Figs 8a and 8b are derived, of course, from Eq 8. The first applies to 60-Hz power-line frequencies ($1/T_v = 60$ Hz); the second, to 50-Hz cases.

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Author's biography

Jeff Wolking—is currently pursuing his MBA degree at the Wharton School. He wrote this article while working as a summer employee in the marketing department of Hewlett-Packard's Rockaway, NJ facility. Jeff earned a BSEE at the Univ of Calif at Irvine and hopes to complete his MBA this May; he has also spent 2 yrs with Rockwell International, working on secure systems and VLF communications. Jeff enjoys tennis, swimming and oenology in his free time.



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Synchronous static CMOS RAMs increase system performance

It's a challenge to design a RAM array with synchronous memories, but an ever-increasing number of μ Cs can benefit from their use.

Charles Hochstedler, Harris Corp

Synchronous RAMs offer faster access times, lower power dissipation and easier common-bus interfacing than equivalent asynchronous designs. But effectively utilizing these devices in your memory system requires understanding how they operate.

A synchronous RAM derives its name from the fact that the chip-enable signal synchronizes the memory's internal operations with external-system timing demands (Fig 1). Because access is initiated by this signal's falling edge, a synchronous RAM's access time is usually 30 to 40% faster than that of an equivalent asynchronous device. Additionally, a synchronous RAM uses the chip-enable HIGH time before every access to prepare itself by presetting (or precharging) the condition of key internal nodes—an operation that allows you to optimize the condition of critical timing paths to ensure the fastest possible access.

By contrast, an asynchronous RAM has no signal available to indicate that an access operation is about to begin. And no precharging

operations are possible because the chip-select signal can remain LOW throughout many successive cycles.

Note that synchronous memory operation (often called clocked operation) is not identical to dynamic-memory refresh. Synchronous static memory utilizes the common 6-transistor, fully static, latch-type cell; chip enable is used to increase performance, not to refresh data.

Easier on the draw, too

Lower operating power than asynchronous devices is a second major benefit afforded by synchronous techniques—a comparison that's valid, of course, only between RAMs using identical technologies: (You can't compare the power dissipation of CMOS units with that of NMOS devices.)

Because in synchronous CMOS designs, power consumption becomes a function of the frequency of repetitive accessing plus a small leakage current, the memory consumes power only when it is in active use. It consequently conserves

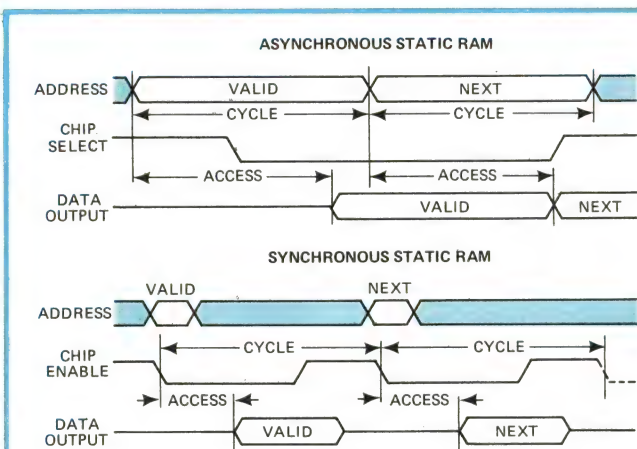


Fig 1—A marked difference in access time appears in these timing diagrams for typical RAM devices. In addition to exhibiting faster access, the synchronous RAM has less stringent requirements for maintaining valid address inputs.

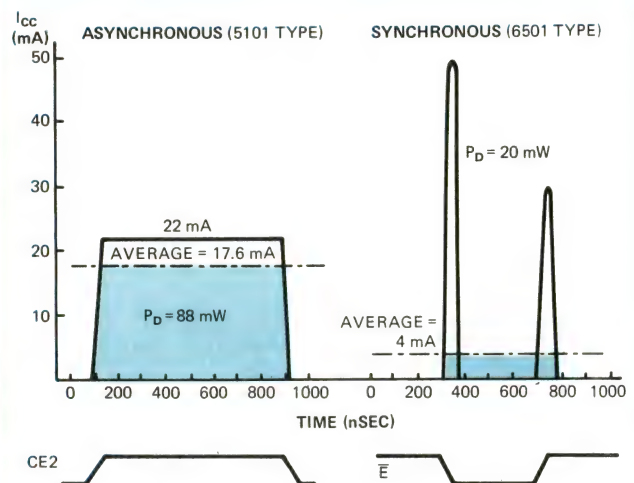


Fig 2—Average power dissipation is dramatically lower in synchronous RAMs than in equivalent asynchronous memories, despite the fact that peak current demands are much higher.

Power is lower, even though peak current is higher

power when not being accessed. In contrast, an asynchronous CMOS RAM requires dc current paths and consumes power whenever enabled.

Fig 2 charts the relationship between chip-enable waveforms and supply current for two pin-compatible devices—one synchronous, the other asynchronous. As shown, the synchronous 6501 draws a higher peak current. However, these peaks are so narrow that the asynchronous 5101 has more than four times the power dissipation. The table summarizes the speed and power specifications for both standard and prime grades of the 5101 and 6501.

Multiplexed bus structures made easy

The differences in RAM addressing between synchronous and asynchronous units highlight another point in favor of synchronous memories. Because these units require such a short valid-address time, it's easy to implement common address, data-in and data-out bus systems using them. And because in a synchronous-RAM array, valid data output need not be timed to coincide with valid address information, address informa-

SPEED AND POWER COMPARISONS FOR CMOS STATIC RAMs

	ASYNCHRONOUS 5101 ⁽¹⁾		SYNCHRONOUS 6501	
	STANDARD	PRIME	STANDARD	PRIME
MAXIMUM ACCESS (nSEC)	650	450	300	220
MINIMUM CYCLE (nSEC)	650	450	400	320
MAXIMUM STANDBY (μ A)	200	10	100	10
MAXIMUM OPERATING (mA) ⁽²⁾	22	22	4	4
TYPICAL ACCESS (nSEC) ⁽³⁾	—	—	160	120
TYPICAL CYCLE (nSEC) ⁽³⁾	—	—	210	170
TYPICAL STANDBY (μ A) ⁽³⁾	—	—	1	0.1
TYPICAL OPERATING (mA) ⁽³⁾	9	9	1.5	1.5

NOTES

⁽¹⁾ 5101 SPECIFICATIONS FROM 1978 INTEL DATA CATALOG

⁽²⁾ SYNCHRONOUS OPERATING CURRENT SPECIFIED AT REPETITIVE ACCESS RATE OF 1 MHz

⁽³⁾ TYPICAL PARAMETERS SPECIFIED AT 25°C, 5V

Defining some terms

When using a conventional asynchronous RAM, you must hold its address inputs valid throughout a read or write cycle; this address, together with the device selected, defines the cycle time. If necessary, you can reaccess the RAM while still in this initial select mode.

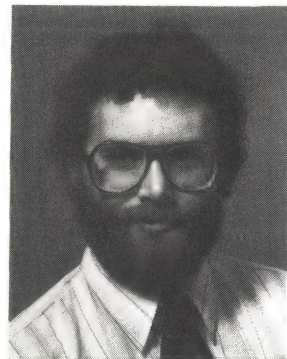
With a synchronous static RAM, on the other hand, you only need a valid address for a short time at the beginning of a cycle. However, cycle initiation requires an edge or transition of the chip-enable signal. Additionally, a finite period of time occurs after access, during which the device must be disabled before the next cycle can begin.

tion and data do not overlap, and it's easy to multiplex these signals on a single bus.

Although at first glance, this type of multiplexed bus structure appears a bit complex, many μ P manufacturers are using it to keep pin counts at a reasonable level. And as more μ Ps appear with common address and data-bus structures, the usefulness of synchronous RAMs with internal address latches will increase. **EDN**

Author's biography

Charles Hochstedler is a memory-applications engineer at Harris' Semiconductor Products Div, Melbourne, FL, where he provides customer applications support and generates information for data sheets and application notes. Charles earned his BS degree in electrical engineering technology at Purdue Univ. His spare-time interests include personal computing, sailing and chess.



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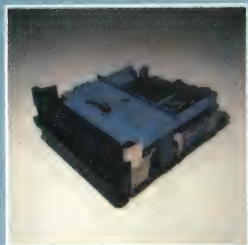
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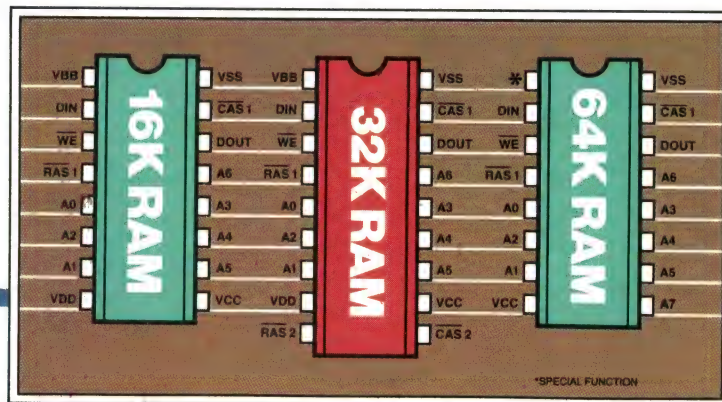
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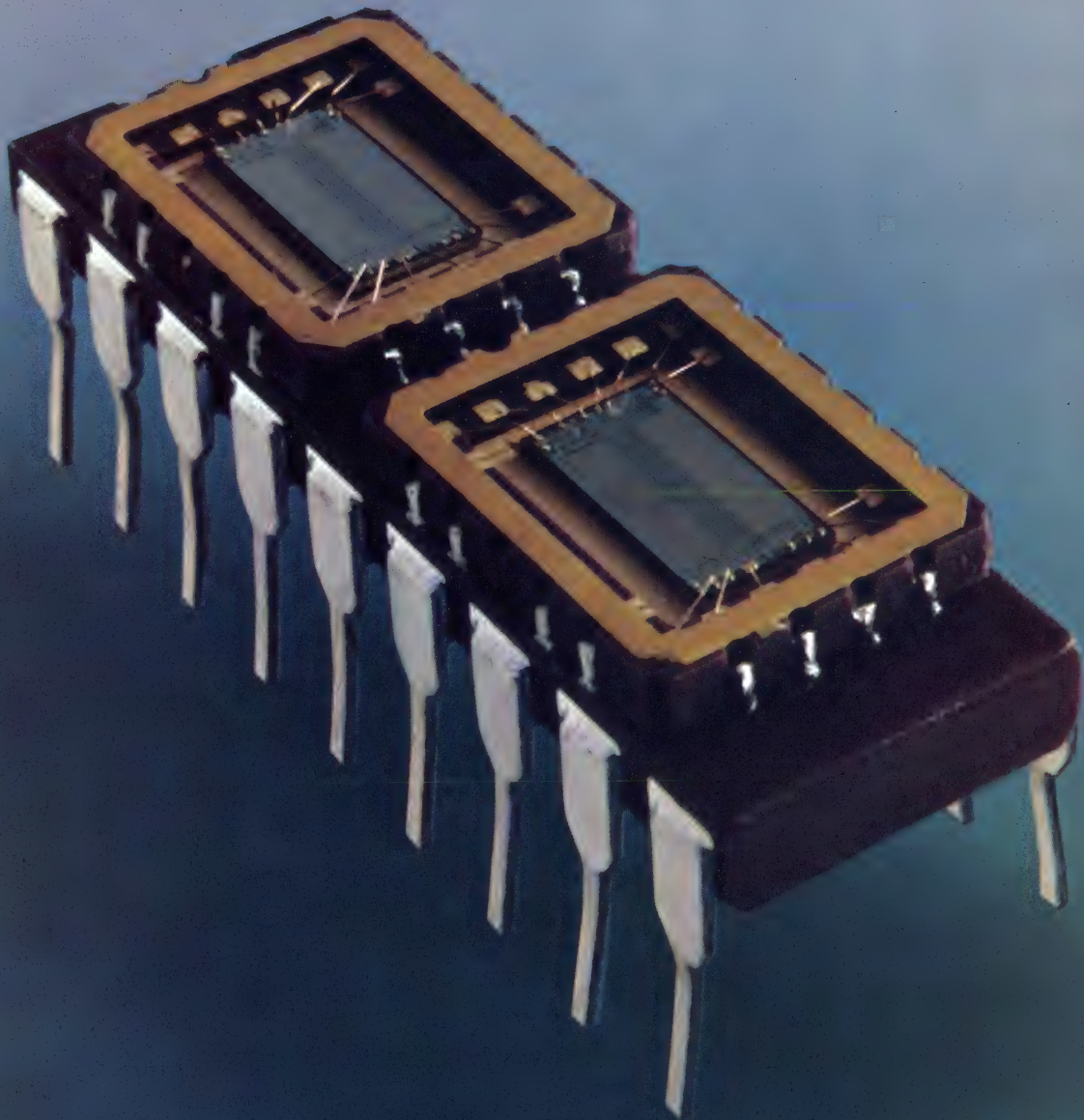
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Learn the peculiarities of low-end- μ C architectures

The odd architectures and instruction sets of low-end, calculator-based 1-chip μ Cs are very cost effective—if you know how to take advantage of them.

Robert H Cushman, Special Features Editor

Because they have so many curious features, today's calculator-like 1-chip μ Cs demand more individual study than their minicomputer-like, midrange- μ P relatives—a realization that grew clearer when we began research for the article originally scheduled for this issue. The advantages of using these versatile low-end devices are lost without adequate groundwork; underestimating the amount of groundwork required can be fatal. And so we have postponed that article—describing an industrial-control application of the National Semiconductor COP402 emulator—until next time. Here we focus on delving more deeply into the architectures and instruction sets of today's low-end 1-chip μ Cs.

As in previous articles (Refs 1 and 2) we'll focus on the Texas Instruments TMS-1000, Rockwell PPS-4/1, National COP400 and AMI S2000. These families are described in capsule form in EDN's annual μ P Directory (Ref 3), which also lists two Japanese 1-chip- μ C families (NEC's μ COM-43 and Panasonic's MN1400) belonging to this calculator-derived category. To a lesser degree, some of the other low-end 1-chip μ Cs—the Intel 8048, General Instrument PIC1650 and Zilog Z8, for example—have similar features.

Split architectures are the rule

The most obvious architectural feature of the calculator-derived μ Cs is the way they are split into three distinct parts: program ROM, data RAM and I/O (Fig 1). From the perspective of computer history, these split-up organizations would appear to be throwbacks to the early "Harvard" architectures—the opposite of the

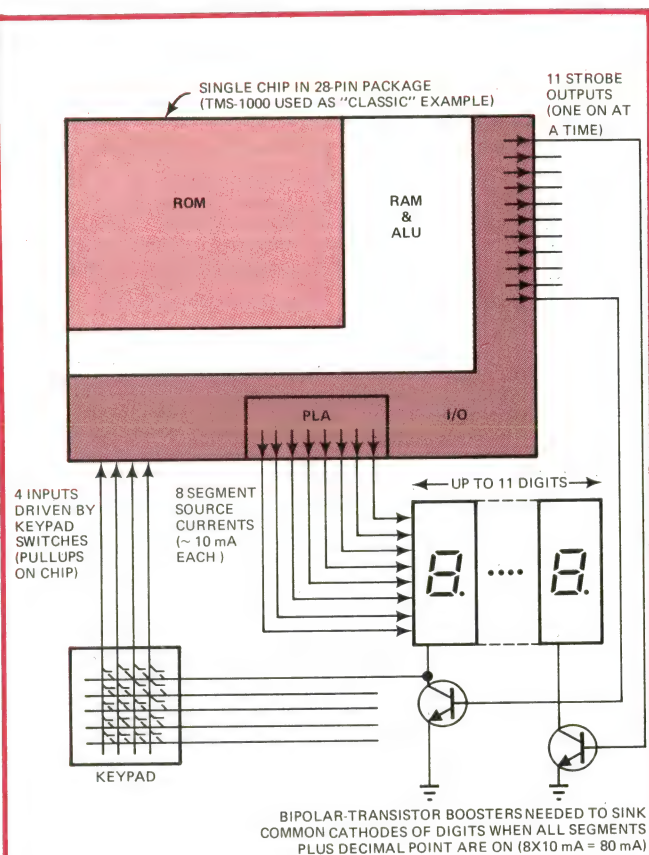


Fig 1—In a typical calculator system, there is ideally only one semiconductor device: the LSI " μ C" itself. Internally, this device divides into three subsystems—program ROM, data RAM and I/O. Externally, the I/O interfaces as directly as possible with a numeric keypad input and a multidigit 7-segment-plus-decimal-point display. Multiplexing via strobe outputs from the LSI device saves pins—an approach that's possible despite the slow clock speeds because the system is used by a human operator. Except when the tiniest LED displays are used, external transistors must sink the displays' common cathodes.

Low-end 1-chippers optimize RAM, ROM and I/O separately

now-prevailing "Princeton" configurations, in which program and data (and often also I/O) share a common memory space.

A compelling reason for adopting the single memory space of Princeton architectures is that with it, one instruction set can apply uniformly to program, data and I/O. The programmer can freely merge these subsystems in a sophisticated, fluid manner, and the single instruction set is supposedly easier to remember and troubleshoot. Indeed, the advance sales publicity for the forthcoming Z8000 and 68000 "super μ Ps" has been extolling the benefits of the uniform instruction sets resulting from "clean" Princeton architecture.

As Fig 2 shows, though, there isn't enough spare silicon in the tiny low-end 1-chip μ Cs to permit the luxury of treating their subsystems identically. Instead, each subsystem is optimized separately to perform its special tasks without forcing design compromises in the name of uniformity. In fact, the different addressing-register reaches, word widths and circuit performances of the three sections *preclude* uniformity.

The architectural differences in the ROM, RAM and I/O sections in turn are responsible for their instruction-set differences. And before you

compare these differences unfavorably with the uniformity prevailing at the higher end of the μ P spectrum, we suggest you first examine how much they can contribute to end-product cost effectiveness.

ROMs have regular 8-bit width

In general, the ROM of a low-end 1-chip μ C is the least "strange" of its subsystems; RAM is slightly "peculiar," and I/O is very specialized.

Most of the calculator-derived μ Cs use byte-sized (8-bit) program words—a width adequate for single-word instructions because the addressing spaces involved in these little machines are so restricted. The width also proves handy during prototyping emulation, because it permits use of standard PROMs and RAMs.

The overriding design criterion for the ROM section is maximum effective code capacity. The greater the amount of effective code you can pack into the ROM, the more competitive your end product. As far as users are concerned, this emphasis on ROM code capacity translates into an emphasis on short, 1-byte instructions. Because an 8-bit byte isn't wide enough to contain the address operand for full-length "long" jumps through the basic 1k ROMs used in the 1-chip μ Cs, various types of "short" jump instructions are provided, typically with 6-bit address operands (and thus 64-byte reaches). Thus, a low-end 1-chip μ C's basic 1k ROM is typically broken up into 16 64-byte pages. The instruction set of the COP400 family (Fig 3) provides an example.

The compartmentalization of the ROM-address space necessitated by the emphasis on single-byte instructions also leads to a number of "nuisance" rules and restrictions for jump and call instructions. Here's an overview of these restrictions for the TMS-1000, COP400 family, S2000 and PPS-4/1:

- The earliest of the designs, the TMS-1000 is also the most primitive; it has only six bits in its PC (program counter). Thus the PC can only fetch instructions within one of the 64-byte ROM pages; when it reaches the end of the page, it wraps around and fetches the next instruction from the page's beginning. Unaided, then, the TMS-1000's jump and call instructions only branch execution within a page. If you want the execution to jump to another page, you must insert an LDP (load page buffer immediate) instruction to select that page from among the other 15. In addition, because all branches are conditional and might not occur, you must remember to insert a second LDP before a branch whenever a subroutine-call instruction directs execution to another page. That way, the page buffer will be restored to the original page.

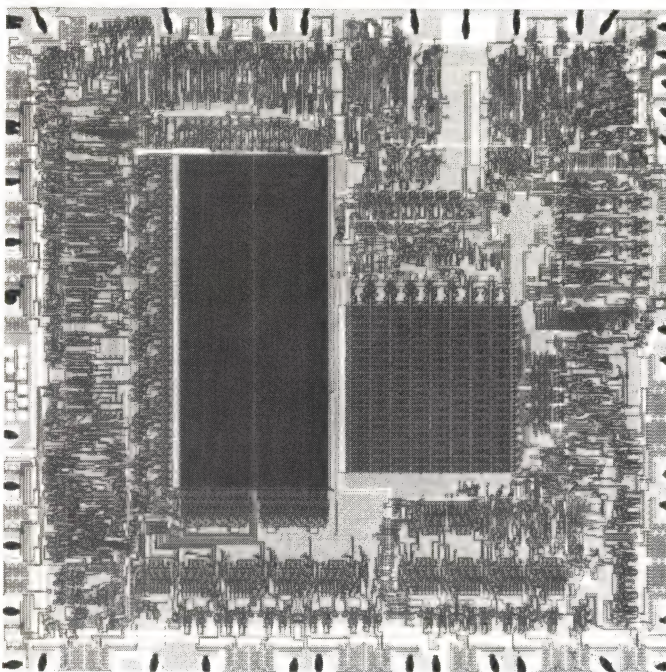


Fig 2—In the latest addition to AMI's S2000 family—the S2150—ROM and RAM are easily recognized, as are the large I/O devices around the edge. The original S2000 chip measures 162×172 mils, and the S2150 is not much larger (178×173) despite its 50%-larger ROM and 25%-larger RAM. The forthcoming S2200 and S2400, with their 2k and 4k ROMs, will measure 180×180 and 180×218 mils, respectively. Their on-chip, 8-channel, 8-bit A/D converters will occupy only 500 mil².

- The COP420 has a full 10-bit PC but nevertheless also uses 64-byte paging to provide short jumps and calls (Fig 4). A further complication: Pages 2 and 3 of the 16 ROM pages are treated as "subroutine pages"; the short-form JP (jump) instruction, which normally can only initiate a jump within a 64-byte page, can also cause a jump to one of these subroutine pages from the other. (Because the COP's PC preincrements before the instruction fetch, you must remember to treat the last address on a page as part of the next page.) The COP400 family's short-form subroutine call, JSRP, is a 1-byte instruction that permits jumping to subroutines in pages 2 or 3 from any other page. It's an efficient way of moving program execution to the subroutine pages; once execution is there, though, any further levels of subroutining must be called by the long-form, 2-byte JSR instruction. This requirement is unfortunate, because unlike the TMS-1000 (which is restricted to just one level of subroutine call), the COP400 family can nest up to three levels (if no interrupt is expected).
- The S2000 resembles the COP400 devices in that it has a full 10-bit PC and three levels of subroutine stack. But this μ C achieves short-form program jumps in a manner more akin to that used by the TMS-1000. Jumps must be preceded by a PP (prepare page) instruction. If, in addition to jumping within the internal 1k ROM, you wish to jump to one of up to seven externally addressed 1k banks, you must insert two PP instructions in tandem—the first to prepare the bank address and the second to select the page address. The S2000 architecture treats page 15 (in any of the 1k banks) as the subroutine page. The μ C's JMS (jump to subroutine) instruction automatically sets the page register to 15 unless it is overridden by a preceding PP instruction.
- The PPS-4/1's ROM architecture resembles those of the COP400 and S2000 families. However, it has a wider PC (11 bits) for directly addressing up to 2k of ROM, and some of its long jumps are a full three bytes long. It also has two levels of subroutine stack. Problems can arise with the multi-byte jump instructions, though, because the PPS-4/1 coding rules don't permit placing skip instructions ahead of these multibyte codes.

Do all these details of ROM addressing for the calculator-derived μ Cs sound confusing? They are at first, but after you've worked with these machines, you quickly catch on and learn to make their idiosyncrasies work for you. Originally, the

manufacturers of these chips were forced to do much of the programming for their customers, but now they say most of those customers are doing their own programming. Based on the number of development systems sold for the calculator-derived μ Cs, we estimate that there could be as many as 10,000 engineers familiar with the techniques of programming them.

RAMs are really CPU-register arrays

Only occasionally are low-end 1-chip μ Cs required to act on 4-bit words. More typically, they either process numbers in the form of strings of BCD digits or set and reset individual flag bits. This operation contrasts with that of larger machines, where the computer's word length is more likely to prove adequate for the data processed.

The tiny RAMs in the calculator-derived μ Cs are therefore organized less like regular memory RAMs than like CPU-register arrays and groups of flag bits. As shown in Fig 4, the two parts of their split address registers typically map these RAMs into four long 16-word strings. The strings' individual words or "digits" are addressed by a 4-bit lower ("d") register (to use COP-family terminology); the usual four strings of 16 digits are then selected by short 2-bit upper ("r") registers.

The 4-bit d register is usually intimately associated with the accumulator (and, as you'll see later, with one of the I/O ports). The two r bits are treated somewhat like the upper bits of the PC addressing the ROM; they should ideally be initialized only occasionally, although they might, in reality, get flipped-about frequently during program execution.

This split-up RAM-addressing scheme nicely suits the design goals for low-end 1-chip μ Cs: It produces maximum ROM-code density, because it permits packing RAM-addressing operands into 1-byte instructions. And because many of these RAM-referencing instructions are constantly used in typical application programs, it is essential that they be short. Further, because they are typically used in program loops, they can have a critical effect upon program execution speed—again, shortness pays off.

A look at the COP instruction set (Fig 3) shows why the μ C's architecture permits short, fast instructions. Consider the bit patterns for the XDS and XIS instructions, for example; these complementary commands are the key instructions found in so many numerical data-processing loops. They are single-byte entities, yet they contain the necessary RAM addressing as well as loop housekeeping. Two short software examples illustrate their power.

Suppose first that you want to bring the digits of a numerical string in RAM into the accumula-

Is a multiple- μ C 1-chip device next?

tor one by one, clear them, and return them to RAM. For this purpose, you can use the very short, tight, fast loop shown in Fig 5.

The string of interest in this case comprises the digits 0 to 12 of string 1. An LBI (load RAM-address register B immediate), which initializes both the r and d sections of the RAM-address register B, sets up the operation. The r=01 of this instruction's operand field points at RAM-register string 1, and the d=1011 points at the number 12 digit of that string. The loop itself consists of just three 1-byte instructions:

- The CLRA clears the accumulator.
- The XDS is a multifunction instruction that does practically all the loop's work. It exchanges contents with the pointed-to RAM location, loading in the ZEROS that clear that location. It exclusive-ORs the r address with the r field in the operand—an act that has no effect in this case because the r field is 00. Finally, it decrements the d address to shift the RAM address to the next digit and checks to see if the d part of the address has gone past 0000. If so, it causes the μ C to skip the next instruction.
- The final JP is a short 1-byte jump to the start of the loop. It is skipped when the last digit of the string has been processed because then the d address has gone past 0000. Note that the writer of this program has purposely mapped the string against the right-hand boundary of the RAM so that the XDS skip occurs after the last digit of the

RAM (& ALU) SECTION

Mnemonic	Operand	Hex Code	Machine Language Code (Binary)	Data Flow	Skip Conditions	Description
MEMORY REFERENCE INSTRUCTIONS						
CAMQ		33	[0 0 1 1 0 0 1 1]	A \rightarrow Q7:4 RAM(B) \rightarrow Q3:0	None	Copy A, RAM to Q
		3C	[0 0 1 1 1 1 0 0]			
COMA		33	[0 0 1 1 0 0 1 1]	Q7:4 \rightarrow RAM(B) Q3:0 \rightarrow A	None	Copy Q to RAM, A
		2C	[0 0 1 0 1 1 0 0]			
LD	r	-5	[0 0 r 0 1 0 1]	RAM(B) \rightarrow A Br \oplus r \rightarrow Br	None	Load RAM into A, Exclusive-OR Br with r
LDD	r, d	23	[0 0 1 0 0 0 1 1]	RAM(r, d) \rightarrow A	None	Load A with RAM pointed to directly by r, d
		--	[0 0 r d]			
LQID		BF	[1 0 1 1 1 1 1 1]	ROM(PCg, g, A, M) \rightarrow Q SB \rightarrow SC	None	Load Q Indirect
RMB	0	4C	[0 1 0 0 1 1 0 0]	0 \rightarrow RAM(B) ₀	None	Reset RAM Bit
	1	45	[0 1 0 0 0 1 0 1]	0 \rightarrow RAM(B) ₁		
	2	42	[0 1 0 0 0 0 1 0]	0 \rightarrow RAM(B) ₂		
	3	43	[0 1 0 0 0 0 1 1]	0 \rightarrow RAM(B) ₃		
SMB	0	4D	[0 1 0 0 1 1 0 1]	1 \rightarrow RAM(B) ₀	None	Set RAM Bit
	1	47	[0 1 0 0 0 1 1 1]	1 \rightarrow RAM(B) ₁		
	2	46	[0 1 0 0 0 1 1 0]	1 \rightarrow RAM(B) ₂		
	3	4B	[0 1 0 0 1 1 0 1]	1 \rightarrow RAM(B) ₃		
STII	y	7-	[0 1 1 1 y]	y \rightarrow RAM(B) Bd + 1 \rightarrow Bd	None	Store Memory Immediate and Increment Bd
X	r	-6	[0 0 r 0 1 1 0]	RAM(B) \leftrightarrow A Br \oplus r \rightarrow Br	None	Exchange RAM with A, Exclusive-OR Br with r
XAD	r, d	23	[0 0 1 0 0 0 1 1]	RAM(r, d) \leftrightarrow A	None	Exchange A with RAM pointed to directly by r, d
		--	[1 0 r d]			
XDS	r	-7	[0 0 r 0 1 1 1]	RAM(B) \leftrightarrow A Bd - 1 \rightarrow Bd Br \oplus r \rightarrow Br	Bd decrements past 0	Exchange RAM with A and Decrement Bd, Exclusive-OR Br with r
XIS	r	-4	[0 0 r 0 1 0 0]	RAM(B) \leftrightarrow A Bd + 1 \rightarrow Bd Br \oplus r \rightarrow Br	Bd increments past 15	Exchange RAM with A and Increment Bd, Exclusive-OR Br with r
REGISTER REFERENCE INSTRUCTIONS						
CAB		50	[0 1 0 1 0 0 0 0]	A \rightarrow Bd	None	Copy A to Bd
CBA		4E	[0 1 0 0 1 1 1 0]	Bd \rightarrow A	None	Copy Bd to A
LBI	r, d	--	[0 0 r (d - 1)] (d = 0, 9:15) or [0 0 1 1 0 0 1 1] [1 0 r d] (any d)	r, d \rightarrow B	Skip until not a LBI	Load B Immediate with r, d
LEI	y	33	[0 0 1 1 0 0 1 1]	y \rightarrow EN	None	Load EN Immediate
		6-	[0 1 1 0 y]			
XABR		12	[0 0 0 1 0 0 1 0]	A \leftrightarrow Br (0, 0 \rightarrow A3, A2)	None	Exchange A with Br
ARITHMETIC INSTRUCTIONS						
ASC		30	[0 0 1 1 0 0 0 0]	A + C + RAM(B) \rightarrow A Carry \rightarrow C	Carry	Add with Carry, Skip on Carry
ADD		31	[0 0 1 1 0 0 0 1]	A + RAM(B) \rightarrow A	None	Add A to RAM
ADT		4A	[0 1 0 0 1 0 1 0]	A + 10 ₁₀ \rightarrow A	None	Add Ten to A
AISC	y	5-	[0 1 0 1 y]	A + y \rightarrow A	Carry	Add Immediate, Skip on Carry (y \neq 0)
CASC		10	[0 0 0 1 0 0 0 0]	\bar{A} + RAM(B) + C \rightarrow A Carry \rightarrow C	Carry	Complement and Add with Carry, Skip on Carry
CLRA		00	[0 0 0 0 0 0 0 0]	0 \rightarrow A	None	Clear A
COMP		40	[0 1 0 0 0 0 0 0]	\bar{A} \rightarrow A	None	Ones complement of A to A
NOP		44	[0 1 0 0 0 1 0 0]	None	None	No Operation
RC		32	[0 0 1 1 0 0 1 0]	"0" \rightarrow C	None	Reset C
SC		22	[0 0 1 0 0 0 1 0]	"1" \rightarrow C	None	Set C
XOR		02	[0 0 0 0 0 0 1 0]	A \oplus RAM(B) \rightarrow A	None	Exclusive-OR A with RAM

Fig 3—The instruction set for the COP420 illustrates the separate instruction groups for each of the chip's three subsections. Although you won't be able to fully decipher these instructions because we haven't included important supplemental notes and provisos, you should be able to understand their general structure.

ROM SECTION

Mnemonic	Operand	Hex Code	Machine Language Code (Binary)	Data Flow	Skip Conditions	Description
TRANSFER OF CONTROL INSTRUCTIONS						
JID		FF	1 1 1 1 1 1 1 1	ROM (PC9:8, A, M) → PC7:0	None	Jump Indirect
JMP	a	6--	0 1 1 0 0 0 a9:8 a7:0	a → PC	None	Jump
JP	a	--	1 a6:0 (pages 2, 3 only) or 1 1 a5:0 (all other pages)	a → PC6:0 a → PC5:0	None	Jump within Page
JSRP	a	--	1 0 a5:0	PC + 1 → SA → SB → SC 0010 → PC9:6 a → PC5:0	None	Jump to Subroutine Page
JSR	a	6--	0 1 1 0 1 0 a9:8 a7:0	PC + 1 → SA → SB → SC a → PC	None	Jump to Subroutine
RET		48	0 1 0 0 1 0 0 0	SC → SB → SA → PC	None	Return from Subroutine
RETSK		49	0 1 0 0 1 0 0 1	SC → SB → SA → PC	Always Skip on Return	Return from Subroutine then Skip
TEST INSTRUCTIONS						
SKC		20	0 0 1 0 0 0 0 0		C = "1"	Skip if C is True
SKE		21	0 0 1 0 0 0 0 1		A = RAM(B)	Skip if A Equals RAM
SKGZ		33	0 0 1 1 0 0 1 1		G3:0 = 0	Skip if G is Zero (all 4 bits)
SKGBZ		33	0 0 1 1 0 0 1 1	1st byte		Skip if G Bit is Zero
	0	01	0 0 0 0 0 0 0 1		G0 = 0	
	1	11	0 0 0 1 0 0 0 1		G1 = 0	
	2	03	0 0 0 0 0 0 1 1		G2 = 0	
	3	13	0 0 0 1 0 0 1 1		G3 = 0	
SKMBZ		01	0 0 0 0 0 0 0 1		RAM(B)0 = 0	Skip if RAM Bit is Zero
	1	11	0 0 0 1 0 0 0 1		RAM(B)1 = 0	
	2	03	0 0 0 0 0 0 1 1		RAM(B)2 = 0	
	3	13	0 0 0 1 0 0 1 1		RAM(B)3 = 0	
SKT		41	0 1 0 0 0 0 0 1		A time-base counter carry has occurred since last test.	Skip on Timer

I/O SECTION

Mnemonic	Operand	Hex Code	Machine Language Code (Binary)	Data Flow	Skip Conditions	Description
INPUT/OUTPUT INSTRUCTIONS						
ING		33 2A	0 0 1 1 0 0 1 1 0 0 1 0 1 0 1 0	G → A	None	Input G ports to A
ININ		33 28	0 0 1 1 0 0 1 1 0 0 1 0 1 0 0 0	IN → A	None	Input IN Inputs to A
INIL		33 29	0 0 1 1 0 0 1 1 0 0 1 0 1 0 0 1	IL3, CKO, "0", IL0 → A	None	Input IL Latches to A
INL		33 2E	0 0 1 1 0 0 1 1 0 0 1 0 1 1 1 0	L7:4 → RAM(B) L3:0 → A	None	Input L Ports to RAM, A
OBD		33 3E	0 0 1 1 0 0 1 1 0 0 1 1 1 1 1 0	Bd → D	None	Output Bd to D Outputs
OGI	y	33 5--	0 0 1 1 0 0 1 1 0 1 0 1 y	y → G	None	Output to G Ports Immediate
OMG		33 3A	0 0 1 1 0 0 1 1 0 0 1 1 1 0 1 0	RAM(B) → G	None	Output RAM to G Ports
XAS		4F	0 1 0 0 1 1 1 1	A ↔ SIO, C → SK	None	Exchange A with SIO

INSTRUCTION SET SYMBOLS

Symbol	Definition
INTERNAL ARCHITECTURE SYMBOLS	
A	4-bit Accumulator
B	6-bit RAM Address Register
Br	Upper 2 bits of B (register address)
Bd	Lower 4 bits of B (digit address)
C	1-bit Carry Register
D	4-bit Data Output Port
EN	4-bit Enable Register
G	4-bit Register to latch data for G I/O Port
IL	Two 1-bit Latches associated with the INg or ING Inputs
IN	4-bit Input Port
L	8-bit TRI-STATE I/O Port
M	4-bit contents of RAM Memory Pointed to by B Register
PC	10-bit ROM Address Register (program counter)
Q	8-bit Register to latch data for L I/O Port
SA	10-bit Subroutine Save Register A
SB	10-bit Subroutine Save Register B
SC	10-bit Subroutine Save Register C
SIO	4-bit Shift Register and Counter
SK	Logic-Controlled Clock Output

INSTRUCTION OPERAND SYMBOLS

d	4-bit Operand Field, 0-15 binary (RAM Digit Select)
r	2-bit Operand Field, 0-3 binary (RAM Register Select)
a	10-bit Operand Field, 0-1023 binary (ROM Address)
y	4-bit Operand Field, 0-15 binary (Immediate Data)
RAM(s)	Content & RAM location addressed by s
ROM (t)	Content & ROM location addressed by t

OPERATIONAL SYMBOLS

+	Plus
-	Minus
→	Replaces
↔	Is exchanged with
=	Is equal to
\bar{A}	The ones complement of A
⊕	Exclusive-OR
:	Range of values

Split-up RAM-addressing schemes permit maximum ROM-code density

string has been cleared. Such clever RAM mapping is essential in 1-chip μ Cs (Refs 4 and 5). At this point we should mention a handy feature found in several of the calculator-derived μ Cs. You can create multiple-entry subroutines by starting off with a string of LBIs, with each one setting up a different starting point in RAM. When a subroutine is called, only the first LBI landed upon is executed—all following LBIs are

ignored. With this dodge, you could extend this clear routine to clear any number of different strings in RAM; the main program calls the desired clear by having the jump-to-subroutine command vector to the desired LBI.

Now suppose (as a second example) that you want to add two BCD strings. The code sequence shown in Fig 6 uses the XIS instruction because this example involves working up from the least significant digit. You map the two arguments to be added one above the other, with their most significant digits up against the high end of the RAM strings.

To make the XIS operate alternately on both

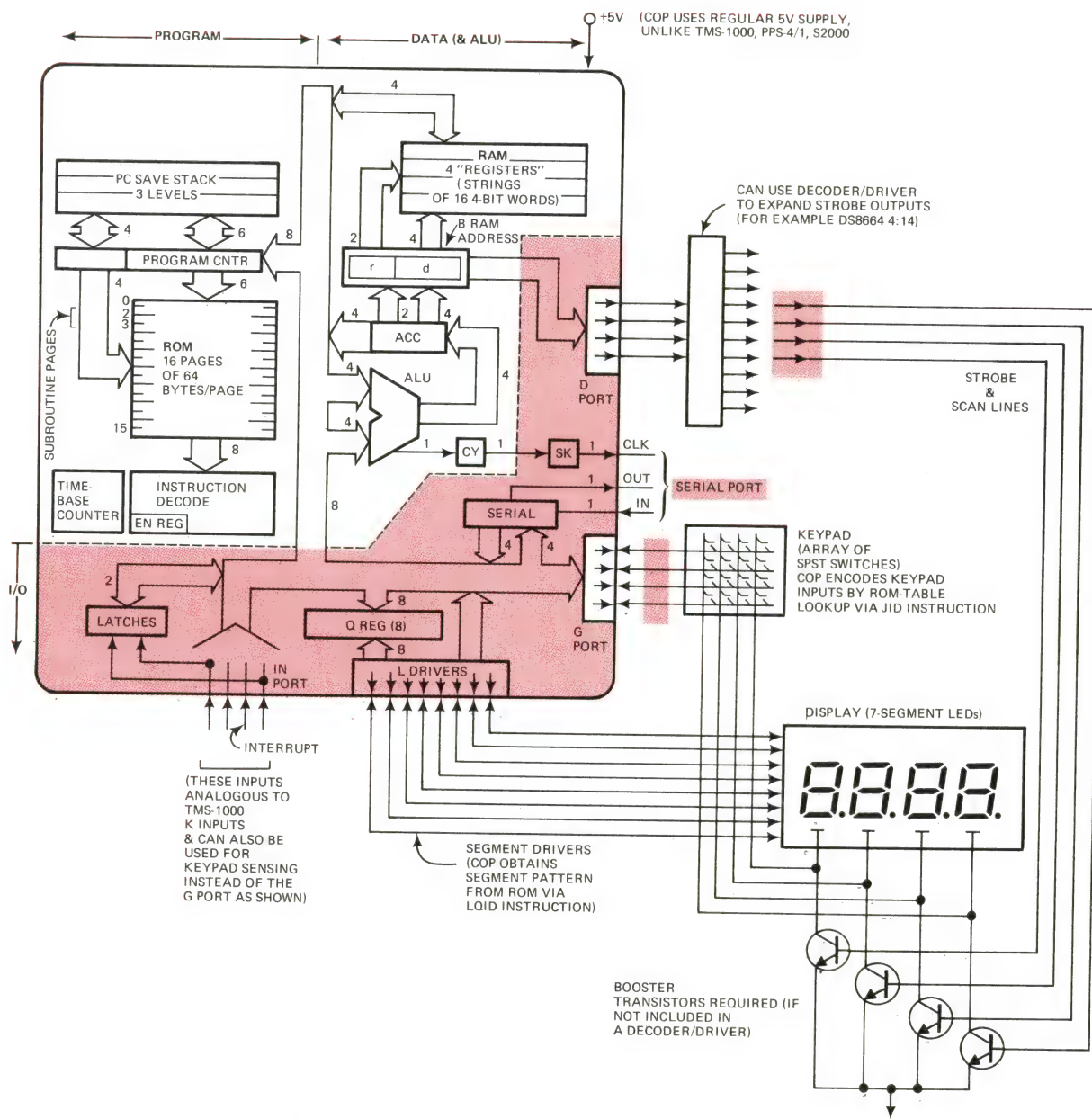


Fig 4—Architecture of the COP420 shows how the chip expands on the basic calculator configuration. Instead of using the same number of I/O pins for the strobes, as most calculators and the TMS-1000 do, National cut the number of strobe outputs to four. The seven freed pins

implement another 4-bit parallel port and a 3-line serial port. Note how many of the pins that were single-function unidirectional lines in the TMS-1000 are now multifunctional and bidirectional, and note the addition of true vectored interrupt on one of the IN pins.

arguments, you need only initialize the RAM-address register once (with the first LBI), and from then on you use the exclusive-ORing feature of XIS's r field to keep flipping back and forth between one string and the other. In the example, the r address for argument 1 is 00, while the r address for argument 2 is 01. Because there is a ONE in the operand field's least-significant-bit position, the exclusive-OR operation causes the least significant bit of the r address to flip back and forth, from ZERO to ONE and then ONE to ZERO. It's hard to imagine a more compact form of relative addressing.

Like the COP400 family, the PPS-4/1 and S2000 also have combined RAM-addressing and loop-control instructions. But the earlier TMS-1000 doesn't, and consequently it suffers in benchmark tests with respect to code compactness and execution speed. However, the TMS-1000 offers users the option of creating more powerful commands through mask-programmed microinstructions; knowledgeable users might thus be able to make it catch up in capability to the newer 1-chip devices.

When low-end 1-chip μ Cs aren't handling BCD strings, they are usually handling individual bits used as flags to remember states of an application's system. All the devices cited here, including the TMS-1000, have instructions that can set, reset and test individual bits in the 4-bit machine words (Fig 3).

However, the bit-manipulation instructions assume that the RAM-address register points at the word containing the desired bit. If that isn't the case (as, for example, with a less inspired arrangement of the RAM-location assignments and program flow), an instruction like the COP LBI must initialize the RAM pointer. (Note that there are two LBIs in the COP instruction set: a short 1-byte LBI and a long 2-byte LBI. Obviously you should try to place the flag bits in words that the short instruction can point to.)

I/O evolved from trials of calculators

To appreciate the peculiar architecture of the calculator-based μ Cs' I/O sections, you must recall what happened in the calculator marketplace during the brutal price wars of the early 1970s. The name of the game then for US manufacturers was combatting the advantage of cheap Asian assembly labor by reducing the number of parts the US products required; it was the only way a US manufacturer could stay in business as retail calculator prices tumbled from \$100 to \$10.

The goal was to have only three essential components:

- The calculator chip itself
- The output display
- The input keyboard.

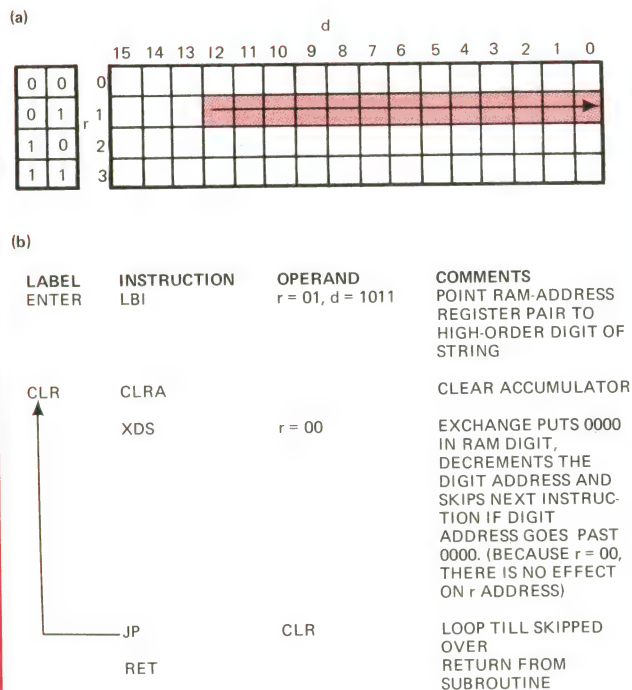


Fig 5—RAM mapping and software clear a COP420 digit string and illustrate how little ROM space is needed if you organize RAM mapping in "calculator" fashion (all instructions are single bytes).

All of these components would ideally mount on one pc board—and that's about all you see inside today's pocket calculators besides the batteries.

The TMS-1000 directly reflects this bare-bones calculator heritage, and part of its immense popularity arises from the way it has brought the economies of \$10 calculator chips within the reach of all product designers.

A diagram in one of our previous articles—Fig 1 of Ref 1—illustrated how closely the TMS-1000's I/O subsystem meets the calculator-market criterion of minimum off-chip parts; Fig 1 in this article shows an I/O configuration that's a capsule rendition of that earlier figure. You can see that the TMS-1000 fails to meet the goal only insofar as it needs external transistors to sink the collective common-cathode currents of the display digits. Each LED is sourced with 10 mA (directly from the TMS-1000), so if all seven segments plus the decimal point are ON, the digit strobe must sink 80 mA—too much to expect of a reasonably sized LSI-device I/O driver. (However, some calculator chips can directly handle the collective digit currents of small displays—for example, the General Instrument C-6XXD/C to C-16XXD Series).

The TMS-1000's 28-pin package has 11 strobe outputs, so the μ C can service 11 digits without external multiplexing. In calculators, these same strobes are used to scan the keyboard matrix, but in most units, except for the most complex

I/O subsystems permit use of a minimum number of parts

scientific calculators (and some of the newer alphanumeric language translators), some strobes are usually left over and are utilized by product designers to expand the TMS-1000's functions beyond mere calculation.

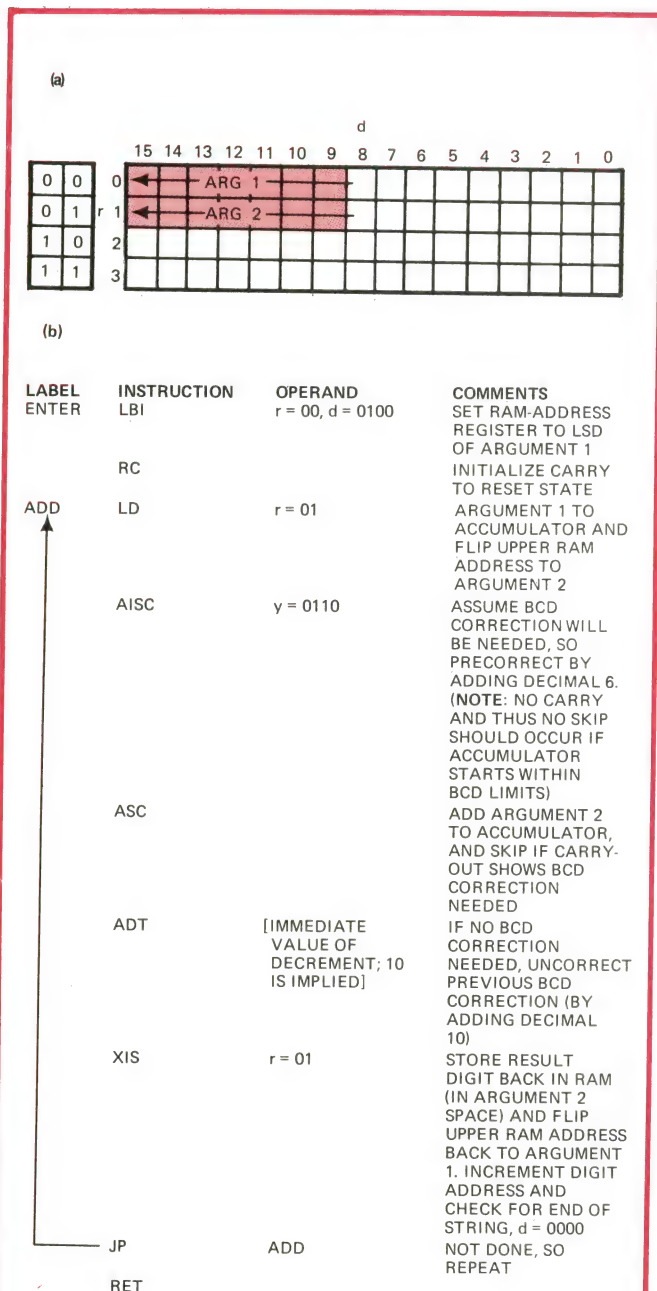


Fig 6—BCD addition of large numbers is something that any calculator should do well, and this COP420 program indicates how few precious ROM bytes the procedure can tie up if coded well. Note the decimal correction, implemented via a "precorrection-then-uncorrect-if-not-needed" process; several of the calculator-derived machines use this technique. An important advantage of the data-RAM section's 4-bit-wide words, compared with RAM in 8-bit machines, is that there is no wasted memory space used to accommodate numbers with an odd number of digits.

Internally, the I/O section's logic helps the TMS-1000 handle the calculator-type servicing of the display and keyboard in several ways. The strobe outputs are driven from the same addressing that accesses digits in the RAM strings. (In terms of the diagram of the COP-420 1-chip μ C architecture—Fig 4—this would be the d part of the B register.) As a result, the digit addressed in the RAM is the same one being refreshed in the display. A PLA associated with the segment outputs in the TMS-1000 aids the process by automatically translating each BCD digit into a 7-segment (or other) pattern.

The TMS-1000 has only four inputs. Many designers now consider that too few, but four are all that most calculator applications require, and the 4-bit-wide port matches up nicely with the 4-bit-wide data words on the RAM side of the machine. While the TMS-1000 can handle more inputs than shown in the illustration by means of further input multiplexing with the available leftover strobe outputs, these extra inputs—if they are other than the simple spst switches of keyboards—demand further external devices. Furthermore, the TMS-1000 has no interrupts, so it is usually restricted to handling external events within the rhythm of its basic repeating keyboard- and display-scanning loop.

The I/O sections of the newer μ Cs—the PPS-4/1, COP400 and S2000—are all variations and elaborations upon the TMS-1000 structure. These μ Cs' designers have tried to strengthen the strong points of the TMS-1000 architecture while adding flexibility and generality.

An I/O variation

Like the TMS-1000, the COP420 also comes in a small 28-pin package. National has attempted to redistribute the μ C's I/O resources to make it a more general-purpose controller; the firm has traded off some of the strobe outputs in favor of a 4-bit bidirectional port and a 3-line (one input, one output, one clock) serial I/O port. Thus, whereas the TMS-1000 has 11 strobe outputs, the COP420 has only four.

If a COP420 user wants to strobe more display digits than just four, he must add an external 4-to-16 decoder. This addition isn't necessarily a disadvantage, because available low-cost TTL decoders provide both the decoding and the high-current sinking for display digits.

The COP's serial I/O isn't too flexible—it only operates synchronously with the COP clock—but it provides (among other things) a handy means for communicating with low-cost shift-register devices and other COP units. For example, you could tie an inexpensive 8-pin miniDIP CMOS shift register to this port for additional nonvolatile RAM. If you don't need a serial port, you can software-program this same shift register to act

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COP400 family is to retain the economies of a TMS-1000-class device but also broaden the device's general-purpose usefulness by offering a wide range of hardware and software options. The most extreme of these options, device-mask, permits direct connection to the midrange 8080's 8-bit bus—an action that uses up most of the I/O that would normally serve for calculating the classic calculator-type keyboard-display scan. But the COP device still has enough remaining ports to be used—with external logic or another COP device linked to it via the serial port—for a surprising variety of applications. Computer-system manufacturers are utilizing this part as an intelligent link to peripherals, according to National. The firm is also producing a preprogrammed version that services an alphanumeric keyboard and display.

In the S2000, AMI has taken a somewhat different tack in I/O-subsystem implementation than National has. Rather than trying to maintain the smallest possible chip sizes and thereby keep cost low, the firm has sought to produce a Cadillac version of the TMS-1000, even if that approach uses more chip area and puts the μ C at the high end of the 1-chip calculator-based- μ C marketplace. For example, AMI uses a special

though the AMI chip is NMOS. The firm also includes I/O to directly handle capacitive touch-keyboard inputs (the type popular in microwave ovens). Part of this I/O capability is an input that detects analog thresholds. And future S2000-family chips will incorporate 8-bit A/D converters and up to 4k of ROM.

Before we began to get hands-on experience with the low-end, calculator-derived 1-chip μ Cs, we had assumed they were just a passing fad—a case of calculator suppliers' trying to cash in on the μ P bonanza. Now we've reversed our opinion. Far from being makeshift, hand-me-down expedients, calculator-derived architectures appear to be nearly optimum for use in low-end markets.

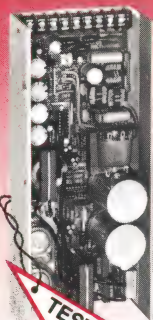
Actually, the 1-chip μ C's multiplexed-I/O structure should also suit many electromechanical and simple electronic interfaces as well. A system's keyboard matrix's spst switches could be replaced by any similar device, from reed switches to snap-action limit units; any of the many variable-resistance, 2-terminal electronic devices, from photocells to thermistors, could also substitute for these keyboard switches. Similarly, the display's LEDs could be replaced by a whole host of output actuators.

The Microbus option and the serial I/O of National's COP family also portend how the \$1 to \$3 chips could be linked into the larger multiprocessing systems of the future, adding credibility to our thesis that 1-chip μ Cs will evolve into the equivalents of TTL building blocks. One National source has even predicted that you'll be seeing multiples of these computers on single chips. **EDN**

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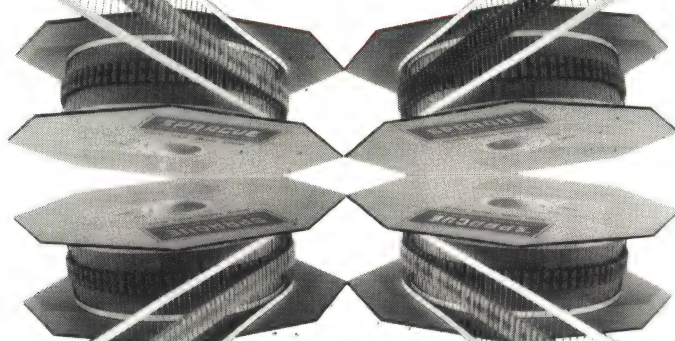
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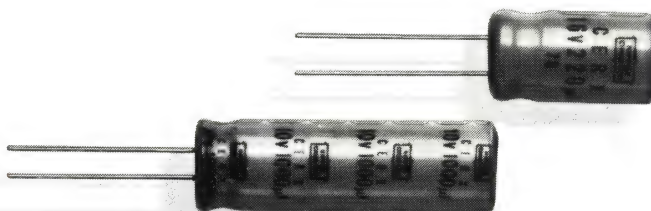
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Design Ideas

Conversion circuit handles binary or BCD

R Srinivasan, R Ramesh and D K Murthi
National Aeronautical Lab, Bangalore, India

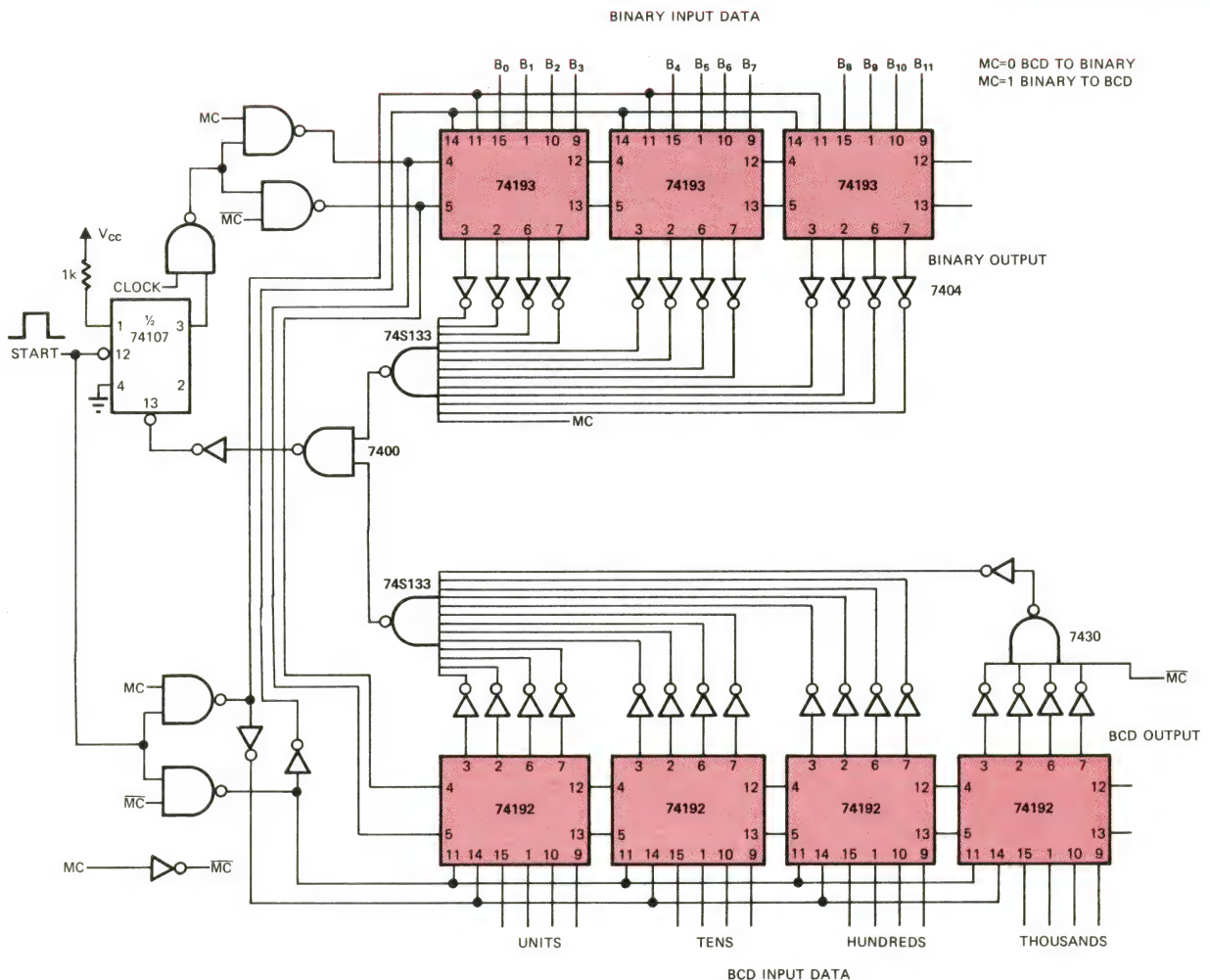
Systems requiring arithmetic operations on data usually perform those operations in binary form. As a result, they must convert the data to BCD form for display purposes. Address-selection information from digit switches, on the other hand, must be converted to binary form for use in memory-addressing operations.

For applications not requiring fast conversion, a single circuit that can perform both

conversions proves adequate. One such circuit (see figure) utilizes up/down counters to obtain the desired results. To perform binary-to-BCD conversion, preset the binary value in the binary counter and clear the BCD counter. The binary counter counts down while the BCD counter counts up, and when the binary counter reaches zero, the BCD counter holds. For BCD-to-binary operation, the BCD counter counts down from the BCD value while the binary counter counts up.

EDN

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Separate binary and BCD up/down counters permit both binary-to-BCD and BCD-to-binary conversion in one circuit.

Comparator detects frequency

Robert Pease

National Semiconductor, Santa Clara, CA

A quad comparator forms the basis of a frequency detector (**figure**) that is faster and less expensive than more complex versions designed around F/V-converter chips.

Positive feedback through a 5-M Ω resistor allows the circuit to resolve changes as small as 2%; the output responds to those changes in about one cycle. When the input frequency is

high, V_2 is pulled LOW, it's never allowed to exceed $2/3V_S$. When the input frequency is lower than the limit, V_2 exceeds $2/3V_S$ once each cycle, but V_3 is held below that limit.

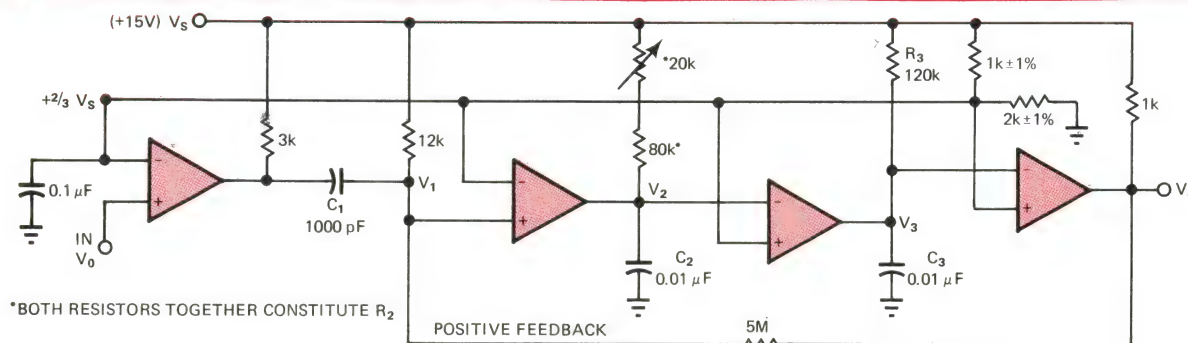
The trip frequency is defined by

$$F = 1/(1.1R_s C_s).$$

You can adjust R_2 to permit trimming of the trip point, but R_3 must remain larger than R_1 .

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A single quad comparator finds use in a fast and simple frequency-detector circuit.

Op amp provides linear current source

Donald E Hall

Tektronix Inc, Beaverton, OR

A common 2-transistor differential amplifier provides a simple voltage-controlled method for driving circuits requiring such inputs. This approach, however, suffers from irregularities over much of the source's dynamic range, producing the familiar characteristic shown in **Fig 1**. Notice in this example that for operation with less than 1% nonlinearity, differential base voltage must remain within a $\pm 26\text{-mV}$ range—leaving a large portion of the dynamic range unused.

An improved circuit (**Fig 2**) uses a 741 op amp to overcome nonlinearity. With ideal op-amp response, the transfer function is described by

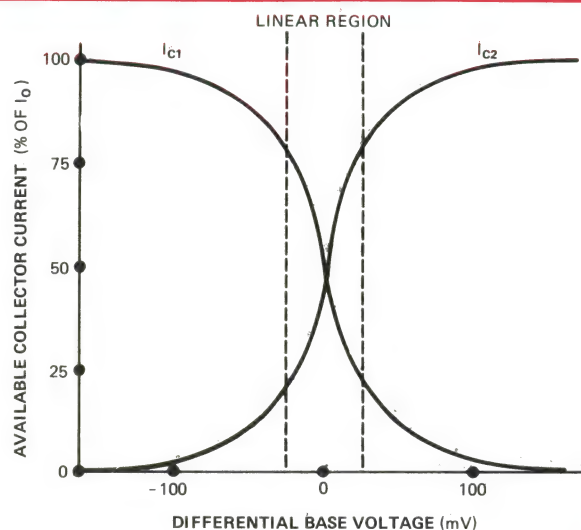


Fig 1—A typical 2-transistor differential amplifier proves linear only within a narrow range of base voltages.

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—Gambera

"We had a crisis on our hands."—Morris

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Armand Gambera, Engineering Supervisor/Portable Products. Larry Morris, Engineering Supervisor/SAS Systems. Telecommunications Technology, Inc., Sunnyvale, CA.

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compiled FORTH in one day. It would have taken a week in assembler. And something that might take 30 hours to debug in another language takes two hours in FORTH. Editing is extremely simple."

"FORTH gives us the nuts-and-bolts control of Assembler without all the tedious coding."—Morris

"FORTH gives us better control over run time. It's very close to the micro-processor in terms of definitions so you can configure as you like, right at the hardware level. That's especially important to us since we have a lot of interfaces, a lot of driver routines."

"My advice to others is: 'Try It!'"—Gambera

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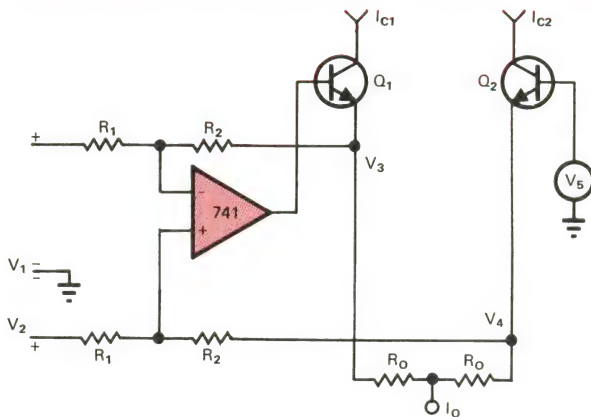


Fig 2—Adding an op amp linearizes the output of the current source.

$$(V_3 - V_4)/(V_2 - V_1) = R_2/R_1.$$

Because

$$I_{C1} - I_{C2} = (V_3 - V_4)/R_0,$$

then

$$(I_{C1} - I_{C2})/(V_2 - V_1) = R_2/R_0R_1.$$

This relationship indicates that even though transconductance of individual transistors can change, the op amp maintains a linear relationship in the current source. Linear opera-

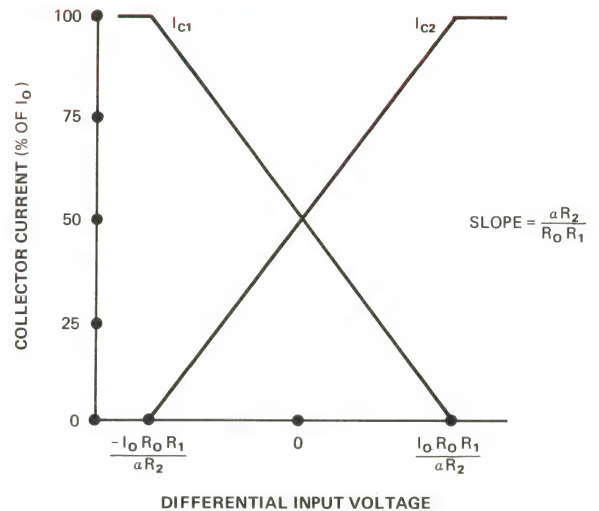


Fig 3—The improvement in linearity effects a significant increase in the circuit's dynamic range.

tion continues until I_{C1} or I_{C2} equals I_0 , as shown in Fig 3.

EDN

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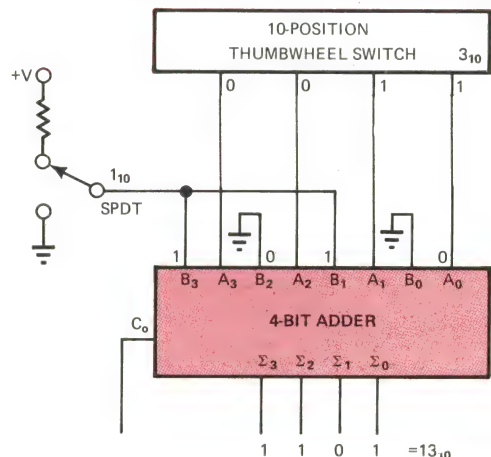
Single chip converts BCD to binary

Vaughn Martin

ITT Aerospace/Optical, Ft Wayne, IN

One 4-bit full adder with a carryout and a spdt switch can convert any BCD number up to 19 into its binary equivalent. The adder's A inputs accept the number's least significant digits from a 10-position BCD thumbswitch; the spdt switch provides the tens-place information. Held HIGH, the switch represents a 10; LOW, a zero. The figure illustrates conversion of the number 13.

The first binary addition of a logic ONE (A_0) and a logic ZERO (B_0) yields a logic ONE (Σ_0); the addition of two logic ONES (A_1 and B_1) yields a logic ZERO (Σ_1) and a carry. The third binary addition of two logic ZEROS (B_2 and A_2) and the carry yield a logic ONE (Σ_2). The last addition, a logic ONE (B_3) plus a logic ZERO (A_3), yields a logic ONE (Σ_3). For numbers greater than 15, the last addition causes a

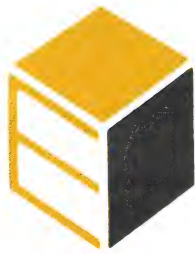


To convert BCD numbers less than 20 into binary form, this simple circuit uses only a 4-bit adder.

carry out (C_0).

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For .0010 thru .033 MFD - See Higher Voltages																							
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.047	.09	.18	.40		650B1A473	26	.022	.09	.18	.40		650B1B223	26	Thru	.09	.18	.40		650B1C	26			
.056	.09	.18	.40		650B1A563	26	.033	.09	.18	.40		650B1B333	26	.015	.09	.18	.40		650B1C153	26			
.068	.09	.18	.40		650B1A683	26	.039	.09	.18	.40		650B1B393	26	.018	.10	.19	.40		650B1C183	26			
.082	.09	.18	.40		650B1A823	26	.047	.09	.18	.40		650B1B473	26	.022	.11	.20	.40		650B1C223	26			
.10	.09	.18	.40		650B1A104	26	.056	.10	.19	.40		650B1B563	26	.027	.09	.18	.53		650B1C273	26			
.12	.09	.18	.40		650B1A124	26	.068	.11	.21	.40		650B1B683	26	.033	.09	.18	.53		650B1C333	26			
.15	.10	.20	.40		650B1A154	26	.082	.09	.18	.53		650B1B823	26	.039	.10	.20	.53		650B1C393	26			
.18	.09	.18	.53		650B1A184	26	.10	.10	.19	.53		650B1B104	26	.047	.11	.21	.53		650B1C473	26			
.22	.09	.18	.53		650B1A224	26	.12	.11	.20	.53		650B1B124	26	.056	.13	.22	.53		650B1C563	24			
.27	.10	.19	.53		650B1A274	26	.15	.12	.22	.53		650B1B154	24	.068	.15	.24	.53		650B1C683	24			
.33	.11	.21	.53		650B1A334	26	.18	.14	.23	.53		650B1B184	24	.082	.16	.26	.53		650B1C823	24			
.39	.13	.22	.53		650B1A394	24	.22	.16	.25	.53		650B1B224	24	.10	.18	.28	.53		650B1C104	24			
.47	.14	.24	.53		650B1A474	24	.27	.18	.28	.53		650B1B274	24	.12	.21	.30	.53		650B1C124	24			
.56	.16	.25	.53		650B1A564	24	.33	.20	.30	.53		650B1B334	24	.15	.23	.33	.53		650B1C124	24			
.68	.18	.27	.53		650B1A684	24	.39	.23	.32	.53		650B1B394	24	.18	.21	.30	.68		650B1C184	24			
.82	.20	.29	.53		650B1A824	24	.47	.20	.30	.68		650B1B474	24	.22	.23	.33	.68		650B1C224	24			
1.0	.22	.32	.53		650B1A105	24	.56	.23	.32	.68		650B1B564	24	.27	.24	.33	.78		650B1C274	24			
1.2	.20	.29	.68		650B1A125	24	.68	.23	.32	.78		650B1B684	24	.33	.27	.36	.78		650B1C334	24			
1.5	.22	.32	.68		650B1A155	24	.82	.25	.35	.78		650B1B824	24	.39	.30	.40	.78		650B1C394	22			
1.8	.23	.32	.78		650B1A185	24	1.0	.28	.38	.78		650B1B105	24	.47	.33	.43	.78		650B1C474	22			
2.0	.24	.34	.78		650B1A205	24	1.2	.31	.41	.78		650B1B125	22	.56	.32	.41	.95		650B1C564	22			
2.5	.26	.37	.78		650B1A255	24	1.5	.37	.48	.95		650B1B155	22	.68	.25	.42	1.17		650B1C684	22			
3.0	.31	.41	.78		650B1A305	22	1.8	.34	.44	.95		650B1B185	22	.82	.28	.45	1.17		650B1C824	22			
3.5	.34	.43	.78		650B1A355	22	2.0	.44	.54	1.17		650B1B205	22	1.0	.32	.49	1.17		650B1C105	22			
4.0	.31	.40	.95		650B1A405	22	2.5	.51	.61	1.17		650B1B255	22	1.2	.36	.52	1.17		650B1C125	20			
4.5	.33	.42	.95		650B1A455	22	3.0	.55	.65	1.17		650B1B305	20	1.5	.41	.58	1.17		650B1C155	20			
5.0	.25	.42	1.17		650B1A505	22	4.0	.61	.71	1.17		650B1B355	20	1.8	.46	.62	1.17		650B1C185	20			
6.0	.28	.45	1.17		650B1A605	22	5.0	.67	.77	1.17		650B1B405	20	2.0	.49	.65	1.17		650B1C205	20			
8.0	.34	.50	1.17		650B1A805	22	6.0	.71	.81	1.17		650B1B455	20	2.5	.47	.64	1.45		650B1C255	20			
10.0	.39	.56	1.17		650B1A106	20	8.0	.77	.87	1.17		650B1B505	20	3.0	.47	.63	1.70		650B1C305	20			
12.0	.43	.60	1.17		650B1A126	20	10.0	.81	.91	1.17		650B1B555	20	3.5	.51	.67	1.70		650B1C355	20			
15.0	.49	.66	1.17		650B1A156	20	12.0	.84	.94	1.17		650B1B605	20	4.0	.50	.66	1.90		650B1C405	20			
18.0	.47	.64	1.45		650B1A186	20	15.0	.91	1.01	1.17		650B1B655	20	4.5	.53	.70	1.90		650B1C455	20			
20.0	.50	.67	1.45		650B1A206	20	18.0	.94	1.04	1.17		650B1B705	20	5.0	.57	.73	1.90		650B1C505	20			
30.0	.56	.73	1.70		650B1A306	20	20.0	.98	1.08	1.17		650B1B755	20	6.0	.63	.79	1.90		650B1C605	20			
40.0	.66	.83	1.70		650B1A406	20						650B1B805	20	8.0	.74	.90	1.90		650B1C805	20			
50.0	.75	.91	1.70		650B1A506	20						650B1B855	20	10.0	.84	1.00	1.90		650B1C106	20			

Epoxy Case

50 VOLT

100 VOLT

200 VOLT

DIMENSIONS													CATALOG PART NUMBER	LEAD SIZE (AWG)	DIMENSIONS													CATALOG PART NUMBER	LEAD SIZE (AWG)
MFD	T			S	MFD	T			S	MFD	T				S														
	±.01"	(MAX.)	±.01"			±.01"	(MAX.)	±.01"			±.01"	(MAX.)				±.01"													
For .0010 thru .068 MFD													See Higher Voltages	For .0010 thru .022 MFD													See Higher Voltages		
.082	18	30	42	300	652A1A823	22	.027	18	30	42	300	652A1B273	22	.0056	18	30	42	300	652A1C562	22									
Thru	18	30	42	300	652A1A	22	.033	18	30	42	300	652A1B333	22	Thru	18	30	42	300	652A1C	22									
.15	18	30	42	300	652A1A154	22	.039	18	30	42	300	652A1B393	22	.015	18	30	42	300	652A1C153	22									
.18	18	30	55	400	652A1A184	22	.047	18	30	42	300	652A1B473	22	.018	18	30	42	300	652A1C183	22									
.22	18	30	55	400	652A1A224	22	.056	18	30	42	300	652A1B563	22	.022	18	30	42	300	652A1C223	22									
.27	18	30	55	400	652A1A274	22	.068	18	30	42	300	652A1B683	22	.027	18	30	55	400	652A1C273	22									
.33	18	30	55	400	652A1A334	22	.082	18	30	55	400	652A1B823	22	.033	18	30	55	400	652A1C333	22									
.39	18	30	55	400	652A1A394	22	.10	18	30	55	400	652A1B104	22	.039	18	30	55	400	652A1C393	22									
.47	24	37	55	400	652A1A474	22	.12	18	30	55	400	652A1B124	22	.047	18	30	55	400	652A1C473	22									
.56	24	37	55	400	652A1A564	22	.15	18	30	55	400	652A1B154	22	.056	24	37	55	400	652A1C563	22									
.68	24	37	55	400	652A1A684	22	.18	24	37	55	400	652A1B184	22	.068	24	37	55	400	652A1C683	22									
.82	30	43	55	400	652A1A824	22	.22	24	37	55	400	652A1B224	22	.082	24	37	55	400	652A1C823	22									
1.0	30	43	55	400	652A1A105	22	.27	24	37	55	400	652A1B274	22	.10	24	37	55	400	652A1C104	22									
1.2	30	43	67	500	652A1A125	22	.33	30	43	55	400	652A1B334	22	.12	30	43	55	400	652A1C124	22									
1.5	30	43	67	500	652A1A155	22	.39	30	43	55	400	652A1B394	22	.15	30	43	55	400	652A1C154	22									
1.8	30	43	82	600	652A1A185	22	.47	30	43	67	500	652A1B474	22	.18	30	43	67	500	652A1C184	22									
2.0	30	43	82	600	652A1A205	22	.56	30	43	67	500	652A1B564	22	.22	30	43	67	500	652A1C224	22									
2.5	40	55	82	600	652A1A255	22	.68	30	43	82	600	652A1B684	22	.27	30	43	82	600	652A1C274	22									
3.0	40	55	82	600	652A1A305	22	.82	40	55	82	600	652A1B824	22	.33	40	55	82	600	652A1C334	20									
3.5	40	55	82	600	652A1A355	20	1.0	40	55	82	600	652A1B105	20	.39	40	55	82	600	652A1C394	20									
4.0	40	55	1.04	800	652A1A405	20	1.2	40	55	1.04	800	652A1B125	20	.47	40	55	82	600	652A1C474	20									
4.5	40	55	1.04	800	652A1A455	20	1.5	40	55	1.04	800	652A1B155	20	.56	40	55	1.04	800	652A1C564	20									
5.0	40	55	1.24	1.100	652A1A505	20	1.8	40	55	1.04	800	652A1B185	20	.68	40	55	1.24	1.100	652A1C684	20									
6.0	40	55	1.24	1.100	652A1A605	20	2.0	40	55	1.24	1.100	652A1B205	20	.82	40	55	1.24	1.100	652A1C824	20									
8.0	40	55	1.24	1.100	652A1A805	20	2.5	40	55	1.24	1.100	652A1B255	20	1.0	40	55	1.24	1.100	652A1C105	20									
10.0	57	73	1.24	1.100	652A1A106	20	3.0	40	55	1.24	1.100	652A1B305	20	1.2	57	73	1.24	1.100	652A1C125	20									
12.0	57	73	1.24	1.100	652A1A126	20	3.5	57	73	1.24	1.100	652A1B355	20	1.5	57	73	1.24	1.100	652A1C155	20									
15.0	57	73	1.24	1.100	652A1A156	20	4.0	57	73	1.24	1.100	652A1B405	20	1.8	57	73	1.24	1.100	652A1C185	20									
18.0	57	73	1.75	1.600	652A1A186	20	4.5	57	73	1.24	1.100	652A1B455	20	2.0	57	73	1.24	1.100	652A1C205	20									
20.0	57	73	1.75	1.600	652A1A206	20	5.0	57	73	1.24	1.100	652A1B505	20	2.5	57	73	1.75	1.600	652A1C255	20									
							6.0	57	73	1.24	1.100	652A1B605	20	3.0	57	73	1.75	1.600	652A1C305	20									
							8.0	57	73	1.75	1.600	652A1B805	20	3.5	57	73	1.75	1.600	652A1C355	20									



Metallized Mylar* Wrap/Fill

100 VOLT

200 VOLT

MFD	DIMENSIONS			CATALOG PART NUMBER	LEAD SIZE (AWG)	MFD	DIMENSIONS			CATALOG PART NUMBER	LEAD SIZE (AWG)
	T ± .05"	W ± .05"	L ± .05"				T ± .05"	W ± .05"	L ± .05"		
For .0010 thru .015 MFD - See Higher Voltages											
.018	.09	.18	.40	23081B183-*	26	.0068	.09	.18	.40	23081C682-*	26
.022	.09	.18	.40	23081B223-	26	.010	.09	.18	.40	23081C103-	26
.033	.09	.18	.40	23081B333-	26	.012	.09	.18	.40	23081C123-	26
.039	.09	.18	.40	23081B393-	26	.015	.09	.18	.40	23081C153-	26
.047	.09	.18	.40	23081B473-	26	.018	.10	.20	.40	23081C183-	26
.056	.09	.18	.40	23081B563-	26	.022	.09	.18	.53	23081C223-	26
.068	.10	.19	.40	23081B683-	26	.027	.09	.18	.53	23081C273-	26
.082	.11	.20	.40	23081B823-	26	.033	.09	.18	.53	23081C333-	26
.10	.09	.18	.53	23081B104-	26	.039	.09	.18	.53	23081C393-	26
.12	.09	.18	.53	23081B124-	26	.047	.09	.18	.53	23081C473-	26
.15	.09	.18	.53	23081B154-	26	.056	.11	.20	.53	23081C563-	26
.18	.09	.18	.53	23081B184-	26	.068	.12	.22	.53	23081C683-	24
.22	.10	.20	.53	23081B224-	26	.082	.14	.23	.53	23081C823-	24
.27	.12	.22	.53	23081B274-	24	.10	.16	.25	.53	23081C104-	24
.33	.14	.23	.53	23081B334-	24	.12	.17	.27	.53	23081C124-	24
.39	.15	.25	.53	23081B394-	24	.15	.20	.29	.53	23081C154-	24
.47	.17	.27	.53	23081B474-	24	.18	.22	.32	.53	23081C184-	24
.56	.19	.28	.53	23081B564-	24	.22	.18	.28	.68	23081C224-	24
.68	.22	.31	.53	23081B684-	24	.27	.20	.29	.68	23081C274-	24
.82	.18	.27	.68	23081B824-	24	.33	.24	.33	.68	23081C334-	24
1.0	.20	.29	.68	23081B105-	24	.39	.21	.30	.78	23081C394-	24
1.2	.22	.32	.68	23081B125-	24	.47	.24	.33	.78	23081C474-	24
1.5	.21	.30	.78	23081B155-	24	.56	.26	.36	.78	23081C564-	24
1.8	.23	.33	.78	23081B185-	24	.68	.29	.39	.78	23081C684-	24
2.0	.25	.34	.78	23081B205-	24	.82	.33	.42	.78	23081C824-	22
3.0	.31	.41	.78	23081B305-	22	1.0	.32	.41	.95	23081C105-	22
4.0	.32	.41	.95	23081B405-	22	1.2	.25	.42	1.17	23081C125-	22
5.0	.26	.42	1.17	23081B505-	22	1.5	.29	.45	1.17	23081C155-	22
6.0	.29	.45	1.17	23081B605-	22	1.8	.32	.49	1.17	23081C185-	22
8.0	.35	.51	1.17	23081B805-	20	2.0	.35	.51	1.17	23081C205-	20
10.0	.46	.63	1.17	23081B106-	20	3.0	.44	.61	1.17	23081C305-	20
12.0	.51	.68	1.17	23081B126-	20	4.0	.44	.61	1.45	23081C405-	20
15.0	.50	.67	1.45	23081B156-	20	5.0	.45	.61	1.70	23081C505-	20
18.0	.56	.72	1.45	23081B186-	20	6.0	.49	.65	1.70	23081C605-	20
20.0	.52	.68	1.70	23081B206-	20	8.0	.53	.70	1.90	23081C805-	20
30.0	.59	.75	1.90	23081B306-	20	10.0	.70	.87	1.90	23081C106-	20
40.0	.72	.88	1.90	23081B406-	20	15.0	.87	1.04	1.90	23081C156-	20
50.0	.79	.95	1.90	23081B506-	20	20.0	1.01	1.18	1.90	23081C206-	20

100 VOLT

Epoxy Case

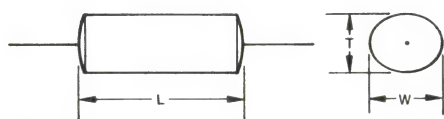
200 VOLT

MFD	DIMENSIONS			S ±.015"	CATALOG PART NUMBER	LEAD SIZE (AWG)	MFD	DIMENSIONS			S ±.015"	CATALOG PART NUMBER	LEAD SIZE (AWG)
	T ±.01"	H (MAX.)	L ±.01"					T ±.01"	H (MAX.)	L ±.01"			
For .0010 thru .018 MFD - See Higher Voltages													
.022	.18	.30	.42	.300	232A1B223-	22	.0082	.18	.30	.42	.300	232A1C822-*	22
.027	.18	.30	.42	.300	232A1B273-	22	.010	.18	.30	.42	.300	232A1C103-	22
.033	.18	.30	.42	.300	232A1B333-	22	.012	.18	.30	.42	.300	232A1C123-	22
.039	.18	.30	.42	.300	232A1B393-	22	.015	.18	.30	.42	.300	232A1C153-	22
.047	.18	.30	.42	.300	232A1B473-	22	.018	.18	.30	.42	.300	232A1C183-	22
.056	.18	.30	.42	.300	232A1B563-	22	.022	.18	.30	.55	.400	232A1C223-	22
.068	.18	.30	.42	.300	232A1B683-	22	.027	.18	.30	.55	.400	232A1C273-	22
.082	.18	.30	.42	.300	232A1B823-	22	.033	.18	.30	.55	.400	232A1C333-	22
.10	.18	.30	.55	.400	232A1B104-	22	.039	.18	.30	.55	.400	232A1C393-	22
.12	.18	.30	.55	.400	232A1B124-	22	.047	.18	.30	.55	.400	232A1C473-	22
.15	.18	.30	.55	.400	232A1B154-	22	.056	.18	.30	.55	.400	232A1C563-	22
.18	.18	.30	.55	.400	232A1B184-	22	.068	.18	.30	.55	.400	232A1C683-	22
.22	.18	.30	.55	.400	232A1B224-	22	.082	.24	.37	.55	.400	232A1C823-	22
.27	.18	.30	.55	.400	232A1B274-	22	.10	.24	.37	.55	.400	232A1C104-	22
.33	.24	.37	.55	.400	232A1B334-	22	.12	.24	.37	.55	.400	232A1C124-	22
.39	.24	.37	.55	.400	232A1B394-	22	.15	.30	.43	.55	.400	232A1C154-	22
.47	.24	.37	.55	.400	232A1B474-	22	.18	.30	.43	.55	.400	232A1C184-	22
.56	.30	.43	.55	.400	232A1B564-	22	.22	.30	.43	.67	.500	232A1C224-	22
.68	.30	.43	.55	.400	232A1B684-	22	.27	.30	.43	.67	.500	232A1C274-	22
.82	.30	.43	.67	.500	232A1B824-	22	.33	.30	.43	.67	.500	232A1C334-	22
1.0	.30	.43	.67	.500	232A1B105-	22	.39	.30	.43	.82	.600	232A1C394-	22
1.2	.30	.43	.67	.500	232A1B125-	22	.47	.30	.43	.82	.600	232A1C474-	22
1.5	.30	.43	.82	.600	232A1B155-	22	.56	.40	.55	.82	.600	232A1C564-	20
1.8	.30	.43	.82	.600	232A1B185-	22	.68	.40	.55	.82	.600	232A1C684-	20
2.0	.40	.55	.82	.600	232A1B205-	20	.82	.40	.55	.82	.600	232A1C824-	20
3.0	.40	.55	.82	.600	232A1B305-	20	1.0	.40	.55	1.04	.800	232A1C105-	20
4.0	.40	.55	1.04	.800	232A1B405-	20	1.2	.40	.55	1.24	1.100	232A1C125-	20
5.0	.40	.55	1.24	1.100	232A1B505-	20	1.5	.40	.55	1.24	1.100	232A1C155-	20
6.0	.40	.55	1.24	1.100	232A1B605-	20	1.8	.40	.55	1.24	1.100	232A1C185-	20
8.0	.57	.73	1.24	1.100	232A1B805-	20	2.0	.57	.73	1.24	1.100	232A1C205-	20
10.0	.57	.73	1.24	1.100	232A1B106-	20	3.0	.57	.73	1.24	1.100	232A1C305-	20
15.0	.57	.73	1.75	1.600	232A1B156-	20	4.0	.57	.73	1.75	1.600	232A1C405-	20
							5.0	.57	.73	1.75	1.600	232A1C505-	20

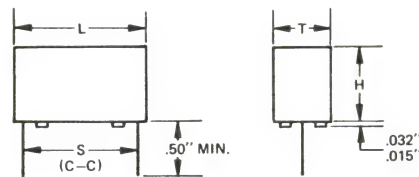
*Add suffix letter to part number for capacitance tolerance desired: $\pm 20\%$ = None $\pm 10\%$ = K $\pm 5\%$ = J $\pm 2\%$ = G $\pm 1\%$ = F.

**Higher voltages and other case styles (round wrap and fill, rectangular epoxy, round and rectangular metal hermetically sealed) are available.

*Mylar is a registered TM of DuPont



LEAD LENGTH: 2.0" + .50"



Miniature High Voltage

1000 VOLT

2000 VOLT

3000 VOLT

DIMENSIONS					CATALOG PART NUMBER	LEAD SIZE (AWG)
MFD	T ± .05"	W ± .05"	L ± .05"			
.001	.12	.32	1.0	52081G102-	20	
.002	.16	.36	1.0	52081G202-	20	
.003	.19	.39	1.0	52081G302-	20	
.005	.21	.41	1.0	52081G502-	20	
.01	.33	.53	1.0	52081G103-	20	
.02	.33	.53	1.3	52081G203-	20	
.03	.41	.61	1.3	52081G303-	20	
.05	.43	.63	1.5	52081G503-	20	
.10	.64	.84	1.5	52081G104-	20	
.20	.79	.99	1.8	52081G204-	20	
.30	1.01	1.21	1.8	52081G304-	20	
.50	.75	1.05	3.3	52081G504-	20	
1.0	.93	1.23	4.3	52081G105-	20	

DIMENSIONS					CATALOG PART NUMBER	LEAD SIZE (AWG)
MFD	T ± .05"	W ± .05"	L ± .05"			
.001	.12	.35	1.0	52081J102-	20	
.002	.19	.39	1.0	52081J202-	20	
.003	.25	.45	1.0	52081J302-	20	
.005	.23	.43	1.3	52081J502-	20	
.01	.34	.54	1.3	52081J103-	20	
.02	.40	.60	1.5	52081J203-	20	
.03	.52	.72	1.5	52081J303-	20	
.05	.45	.65	2.3	52081J503-	20	
.10	.55	.75	3.3	52081J104-	20	
.20	.60	.90	4.3	52081J204-	20	
.30	.76	1.06	4.3	52081J304-	20	
.50	1.02	1.32	4.3	52081J504-	18	
1.0	1.50	1.80	4.3	52081J105-	18	

DIMENSIONS					CATALOG PART NUMBER	LEAD SIZE (AWG)
MFD	T ± .05"	W ± .05"	L ± .05"			
.001	.20	.40	1.0	52081L102-	20	
.002	.26	.46	1.0	52081L202-	20	
.003	.33	.53	1.0	52081L302-	20	
.005	.31	.51	1.3	52081L502-	20	
.01	.46	.66	1.3	52081L103-	20	
.02	.55	.75	1.5	52081L203-	20	
.03	.68	.88	1.5	52081L303-	20	
.05	.61	.81	2.3	52081L503-	20	
.10	.68	.88	3.3	52081L104-	20	
.20	.78	1.08	4.3	52081L204-	20	
.30	1.00	1.30	4.3	52081L304-	18	
.50	1.33	1.63	4.3	52081L504-	18	
1.0	1.95	2.25	4.3	52081L105-	18	

5000 VOLT

8000 VOLT

10,000 VOLT

DIMENSIONS					CATALOG PART NUMBER	LEAD SIZE (AWG)
MFD	T ± .05"	W ± .05"	L ± .05"			
.001	.20	.40	1.3	52081N102-	20	
.002	.27	.50	1.3	52081N202-	20	
.003	.35	.55	1.3	52081N302-	20	
.005	.45	.65	1.3	52081N502-	20	
.01	.52	.72	1.5	52081N103-	20	
.02	.67	.87	1.8	52081N203-	20	
.03	.67	.87	2.3	52081N303-	20	
.05	.88	1.08	2.3	52081N503-	20	
.10	.96	1.18	3.3	52081N104-	18	
.20	1.13	1.43	4.3	52081N204-	18	
.30	1.42	1.72	4.3	52081N304-	18	
.50	1.87	2.17	4.3	52081N504-	18	

DIMENSIONS					CATALOG PART NUMBER	LEAD SIZE (AWG)
MFD	T ± .05"	W ± .05"	L ± .05"			
.001	.35	.55	1.8	52081Y102-	20	
.002	.50	.70	1.8	52081Y202-	20	
.003	.60	.80	1.8	52081Y302-	20	
.005	.65	.85	2.0	52081Y502-	20	
.01	.78	.98	2.5	52081Y103-	20	
.02	.78	.98	3.5	52081Y203-	20	
.03	.99	1.19	3.5	52081Y303-	20	
.05	1.02	1.32	4.5	52081Y503-	18	
.10	1.50	1.80	4.5	52081Y104-	18	
.20						
.30						
.50						

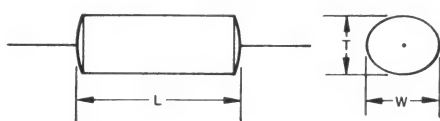
DIMENSIONS					CATALOG PART NUMBER	LEAD SIZE (AWG)
MFD	T ± .05"	W ± .05"	L ± .05"			
.001	.40	.60	1.8	52081S102-	20	
.002	.60	.80	1.8	52081S202-	20	
.003	.60	.80	2.0	52081S302-	20	
.005	.66	.86	2.5	52081S502-	20	
.01	.98	1.18	2.5	52081S103-	20	
.02	.98	1.18	3.5	52081S203-	20	
.03	1.23	1.43	3.5	52081S303-	20	
.05	1.29	1.59	4.5	52081S503-	18	
.10	1.87	2.17	4.5	52081S104-	18	
.20						
.30						
.50						

*Add suffix letter to part number for capacitance tolerance desired: $\pm 20\%$ = None $\pm 10\%$ = K $\pm 5\%$ = J $\pm 2\%$ = G $\pm 1\%$ = F.
 **Higher voltages and other case styles (round wrap and fill, rectangular epoxy, round and rectangular metal hermetically sealed) are available.

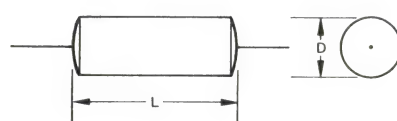
Mylar*/Foil

250B OVAL												TYPE 250D ROUND																															
Cap. Mfd.		200 WVDC			400 WVDC			600 WVDC			Cap. Mfd.		200 WVDC			400 WVDC			600 WVDC																								
		Dash Number	T	W	L	Dash Number	T	W	L	Dash Number			T	W	L	Dash Number	D	L	Dash Number	D	L	Dash Number	D	L																			
.001	(See Higher Voltages)				(See Higher Voltage)																																						
.0015																																											
.0022																																											
.0033					1E332	.11	.20	.53	1F332	.11	.20	.68	.0033	1C332	.14	.53	1E332	.17	.53	1F332	.17	.68																					
.0047					1E472	.11	.20	.68	1F472	.14	.23	.68	.0047	1C472	.14	.53	1E472	.17	.68	1F472	.20	.68																					
.0068					1E682	.11	.20	.68	1F682	.14	.23	.81	.0068	1C682	.14	.53	1E682	.17	.68	1F682	.20	.81																					
.01		1C103	.11	.20	.53	1E103	.14	.23	.68	1F103	.19	.28	.81	.01	1C103	.17	.53	1E103	.20	.68	1F103	.24	.81																				
.015		1C153	.11	.20	.68	1E153	.14	.23	.81	1F153	.20	.29	.81	.015	1C153	.17	.68	1E153	.20	.81	1F153	.25	.81																				
.022		1C223	.14	.23	.68	1E223	.18	.28	.81	1F223	.25	.34	.90	.022	1C223	.20	.68	1E223	.24	.81	1F223	.31	.90																				
.033		1C333	.16	.26	.68	1E333	.20	.29	.81	1F333	.26	.35	.90	.033	1C333	.22	.68	1E333	.26	.81	1F333	.32	.90																				
.047		1C473	.17	.27	.81	1E473	.26	.35	.90	1F473	.33	.42	.90	.047	1C473	.23	.81	1E473	.32	.90	1F473	.39	.90																				
.068		1C683	.18	.28	.81	1E683	.31	.40	.90	1F683	.39	.48	1.17	.068	1C683	.24	.81	1E683	.37	.90	1F683	.45	1.17																				
.10		1C104	.21	.31	.81	1E104	.33	.42	.90	1F104	.41	.57	1.17	.10	1C104	.26	.81	1E104	.39	.90	1F104	.51	1.17																				
.15		1C154	.26	.35	.90	1E154	.39	.48	1.17	1F154	.45	.62	1.45	.15	1C154	.32	.90	1E154	.45	1.17	1F154	.55	1.45																				
.22		1C224	.26	.43	.90	1E224	.41	.57	1.17	1F224	.47	.63	1.45	.22	1C224	.35	.90	1E224	.51	1.17	1F224	.57	1.45																				
.33		1C334	.28	.45	1.17	1E334	.41	.57	1.45	1F334	.59	.75	1.68	.33	1C334	.38	1.17	1E334	.51	1.45	1F334	.69	1.68																				
.47		1C474	.35	.52	1.17	1E474	.47	.63	1.68	1F474	.66	.82	1.90	.47	1C474	.45	1.17	1E474	.57	1.68	1F474	.76	1.90																				
.68		1C684	.41	.57	1.17	1E684	.54	.70	1.90					.68	1C684	.51	1.17	1E684	.64	1.90																							
1.0		1C105	.41	.57	1.45	1E105	.66	.82	1.90					1.0	1C105	.51	1.45	1E105	.76	1.90																							
1.5		1C155	.54	.70	1.45									1.5	1C155	.64	1.45																										
2.0		1C205	.59	.75	1.68									2.0	1C205	.75	1.68																										
TOLERANCE $\pm .050$												LEAD LENGTH $2 \pm \frac{1}{8}$ INCHES																															

*Mylar is a registered TM of DuPont



LEAD LENGTH: $2.0'' \pm .50''$



LEAD LENGTH: $2.0'' \pm .50''$

Metallized Polypropylene

135V (RMS)
270V (RMS)

MFD	DIMENSIONS			PNRP *** mA	POWER (MAX) mW	CATALOG PART NUMBER	LEAD SIZE (AWG)	MFD	DIMENSIONS			PNRP *** mA	POWER (MAX) mW	CATALOG PART NUMBER	LEAD SIZE (AWG)
	T ± .05"	W ± .05"	L ± .05"						T ± .05"	W ± .05"	L ± .05"				
0010	.09	.18	.40	20	80	910B1C102-	26	0010	.12	.21	.68	20	147	910B1E102-	26
0015	.09	.18	.40	20	80	910B1C152-	26	0015	.12	.21	.68	20	147	910B1E152-	26
0022	.09	.18	.40	20	80	910B1C222-	26	0022	.12	.21	.68	20	147	910B1E222-	26
0033	.09	.18	.40	20	80	910B1C332-	26	0033	.12	.21	.68	20	147	910B1E332-	26
0047	.09	.18	.40	20	80	910B1C472-	26	0047	.12	.21	.68	57	147	910B1E472-	26
0068	.09	.18	.40	55	80	910B1C682-	26	0068	.12	.21	.68	83	147	910B1E682-	26
0082	.09	.18	.40	67	80	910B1C822-	26	0082	.12	.21	.68	100	147	910B1E822-	26
010	.09	.18	.40	81	80	910B1C103-	26	010	.12	.21	.68	122	147	910B1E103-	26
015	.09	.18	.53	52	98	910B1C153-	26	015	.16	.25	.68	183	193	910B1C153-	24
022	.09	.18	.53	77	98	910B1C223-	26	022	.20	.29	.68	270	245	910B1E223-	24
033	.12	.21	.53	115	126	910B1C333-	26	033	.17	.26	.95	204	255	910B1E333-	24
047	.15	.24	.53	164	157	910B1C473-	24	047	.21	.30	.95	288	316	910B1E473-	24
068	.18	.28	.53	237	190	910B1C683-	24	068	.26	.35	.95	417	400	910B1E683-	24
082	.20	.30	.53	286	214	910B1C823-	24	082	.28	.38	.95	501	436	910B1E823-	24
.10	.23	.32	.53	349	253	910B1C104-	24	.10	.32	.41	.95	602	511	910B1E104-	22
.15	.22	.32	.68	333	273	910B1C154-	24	.15	.28	.45	1.17	612	598	910B1E154-	22
.22	.23	.33	.78	358	310	910B1C224-	24	.22	.36	.52	1.17	897	756	910B1E224-	20
.33	.30	.39	.78	537	424	910B1C334-	24	.33	.46	.62	1.17	1344	1009	910B1E334-	20
.47	.32	.41	.95	650	511	910B1C474-	22	.47	.47	.64	1.45	1437	1191	910B1E474-	20
.68	.29	.45	1.17	616	598	910B1C684-	22	.68	.46	.63	1.90	1386	1363	910B1E684-	20
.82	.32	.49	1.17	742	686	910B1C824-	22	.82	.52	.69	1.90	1674	1566	910B1E824-	20
1.0	.36	.53	1.17	906	780	910B1C105-	20	1.0	.58	.75	1.90	2040	1781	910B1E105-	20
2.0	.47	.64	1.45	1395	1161	910B1C205-	20	2.0	.86	1.03	1.90	4080	2931	910B1E205-	20
5.0	.64	.81	1.90	2400	1968	910B1C505-	20								
10.0	.94	1.11	1.90	4800	3305	910B1C106-	20								

Polypropylene & Foil

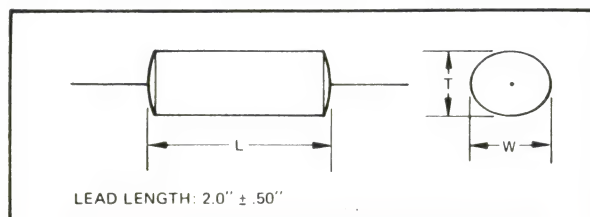
135V (RMS)
270V (RMS)

MFD	DIMENSIONS			PNRP *** AMP	POWER (MAX) mW	CATALOG PART NUMBER	LEAD SIZE (AWG)	MFD	DIMENSIONS			PNRP *** AMP	POWER (MAX) mW	CATALOG PART NUMBER	LEAD SIZE (AWG)
	T ± .05"	W ± .05"	L ± .05"						T ± .05"	W ± .05"	L ± .05"				
0010	.09	.18	.63	2	97	950B1C102-	26	0010	.12	.21	.68	4	147	950B1E102-	26
0015	.09	.18	.63	2	97	950B1C152-	26	0015	.12	.21	.68	4	147	950B1E152-	26
0022	.09	.18	.63	2	97	950B1C222-	26	0022	.12	.21	.68	4	147	950B1E222-	26
0033	.09	.18	.63	2	97	950B1C332-	26	0033	.12	.21	.68	11	147	950B1E332-	26
0047	.09	.18	.63	2	97	950B1C472-	26	0047	.12	.21	.68	16	147	950B1E472-	26
0068	.09	.19	.63	7	97	950B1C682-	26	0068	.13	.23	.68	23	158	950B1E682-	24
0082	.10	.20	.63	8	97	950B1C822-	26	0082	.15	.24	.68	28	181	950B1E822-	24
010	.11	.21	.63	10	97	950B1C103-	26	010	.17	.26	.68	34	206	950B1E103-	24
015	.14	.24	.63	15	126	950B1C153-	24	015	.22	.31	.68	52	273	950B1E153-	24
022	.18	.28	.63	22	167	950B1C223-	24	022	.17	.27	.95	36	255	950B1E223-	24
033	.17	.27	.78	33	214	950B1C333-	24	033	.22	.32	.95	54	332	950B1E333-	24
047	.21	.31	.78	28	209	950B1C473-	24	047	.27	.37	.95	76	418	950B1E473-	24
068	.21	.31	.88	41	287	950B1C683-	24	068	.23	.39	1.17	72	475	950B1E683-	24
082	.24	.34	.88	35	280	950B1C823-	24	082	.26	.42	1.17	87	535	950B1E823-	24
.10	.27	.37	.88	43	310	950B1C104-	24	.10	.29	.46	1.17	106	620	950B1E104-	22
.15	.29	.39	1.05	65	407	950B1C154-	22	.15	.38	.54	1.17	159	804	950B1E154-	20
.22	.26	.43	1.27	75	510	950B1C224-	22	.22	.47	.64	1.17	234	1077	950B1E224-	20
.33	.33	.50	1.27	78	620	950B1C334-	22	.33	.50	.67	1.45	260	1281	950B1E334-	20
.47	.41	.58	1.27	111	780	950B1C474-	20	.47	.48	.65	2.0	244	1430	950B1E474-	20
.68	.39	.56	1.80	160	1009	950B1C684-	20	.68	.60	.77	2.0	354	1855	950B1E684-	20
.82	.43	.60	1.80	192	1147	950B1C824-	20	.82	.67	.83	2.0	426	2084	950B1E824-	20
1.0	.49	.66	1.80	180	1221	950B1C105-	20	1.0	.75	.91	2.0	520	2408	950B1E105-	20
2.0	.66	.83	2.0	244	1744	950B1C205-	20	2.0	1.09	1.26	2.0	1041	4060	950B1E205-	20
5.0	1.09	1.26	2.0	611	3402	950B1C505-	20								

*Add suffix letter to part number for capacitance tolerance desired: $\pm 20\%$ = None $\pm 10\%$ = K $\pm 5\%$ = J $\pm 2\%$ = G $\pm 1\%$ = F.

**Higher voltages and other case styles (round wrap and fill, rectangular epoxy, round and rectangular metal hermetically sealed) are available.

***Peak Non-Repetitive Pulse



Metallized Polysulfone

100 VOLT 200 VOLT

MFD	DIMENSIONS			CATALOG PART NUMBER	LEAD SIZE (AWG)	MFD	DIMENSIONS			CATALOG PART NUMBER	LEAD SIZE (AWG)
	T ± .05"	W ± .05"	L ± .05"				T ± .05"	W ± .05"	L ± .05"		
.0010	.09	.18	.40	81081B102*	26	.0010	.09	.18	.40	81081C102*	26
.0012	.09	.18	.40	81081B122*	26	.0012	.09	.18	.40	81081C122*	26
.0015	.09	.18	.40	81081B152*	26	.0015	.09	.18	.40	81081C152*	26
.0018	.09	.18	.40	81081B182*	26	.0018	.09	.18	.40	81081C182*	26
.0022	.09	.18	.40	81081B222*	26	.0022	.09	.18	.40	81081C222*	26
.0027	.09	.18	.40	81081B272*	26	.0027	.09	.18	.40	81081C272*	26
.0033	.09	.18	.40	81081B332*	26	.0033	.09	.18	.40	81081C332*	26
.0039	.09	.18	.40	81081B392*	26	.0039	.09	.18	.40	81081C392*	26
.0047	.09	.18	.40	81081B472*	26	.0047	.09	.18	.40	81081C472*	26
.0056	.09	.18	.40	81081B562*	26	.0056	.09	.18	.40	81081C562*	26
.0068	.09	.18	.40	81081B682*	26	.0068	.09	.18	.40	81081C682*	26
.0082	.09	.18	.40	81081B822*	26	.0082	.09	.18	.40	81081C822*	26
.010	.09	.18	.40	81081B103	26	.010	.09	.18	.40	81081C103	26
.012	.09	.18	.40	81081B123	26	.012	.09	.18	.40	81081C123	26
.015	.09	.18	.40	81081B153	26	.015	.09	.18	.40	81081C153	24
.018	.09	.18	.40	81081B183	26	.018	.09	.18	.40	81081C183	24
.022	.09	.18	.40	81081B223	26	.022	.09	.18	.40	81081C223	24
.027	.09	.18	.40	81081B273	26	.027	.09	.18	.40	81081C273	24
.033	.09	.18	.40	81081B333	26	.033	.10	.20	.53	81081C333	24
.039	.10	.20	.40	81081B393	26	.039	.11	.21	.53	81081C393	24
.047	.12	.21	.40	81081B473	26	.047	.12	.22	.53	81081C473	24
.056	.18	.29	.53	81081B563	26	.056	.14	.24	.53	81081C563	24
.068	.18	.29	.53	81081B683	26	.068	.16	.26	.53	81081C683	24
.082	.10	.19	.53	81081B823	26	.082	.18	.27	.53	81081C823	24
.12	.11	.20	.53	81081B104	26	.10	.21	.30	.53	81081C104	24
.15	.12	.22	.53	81081B124	24	.12	.24	.32	.53	81081C124	24
.18	.14	.24	.53	81081B154	24	.15	.20	.29	.68	81081C154	24
.22	.16	.25	.53	81081B184	24	.18	.22	.32	.68	81081C184	24
.27	.18	.27	.53	81081B224	24	.22	.21	.30	.78	81081C224	22
.33	.20	.30	.53	81081B274	24	.27	.24	.33	.78	81081C274	22
.39	.22	.32	.53	81081B334	24	.33	.27	.36	.78	81081C334	22
.47	.24	.34	.53	81081B394	24	.47	.32	.42	.78	81081C474	22
.56	.26	.36	.53	81081B474	24	.56	.31	.41	.95	81081C564	22
.68	.22	.32	.78	81081B684	24	.68	.25	.42	1.17	81081C684	22
.82	.25	.34	.78	81081B824	22	.82	.28	.45	1.17	81081C824	22
1.0	.28	.38	.78	81081B105	22	1.0	.32	.49	1.17	81081C105	20
1.2	.32	.41	.78	81081B125	22	1.2	.32	.49	1.17	81081C125	20
1.5	.40	.50	.95	81081B155	22	1.5	.41	.58	1.17	81081C155	20
1.8	.31	.40	.78	81081B185	22	1.8	.46	.63	1.17	81081C185	20
2.0	.36	.45	.78	81081B205	22	2.0	.54	.71	1.30	81081C205	20
2.5	.30	.47	1.17	81081B255	20	2.5	.48	.64	1.45	81081C255	20
3.0	.34	.51	1.17	81081B305	20	3.0	.47	.63	1.70	81081C305	20
3.5	.37	.54	1.17	81081B355	20	3.5	.47	.63	1.90	81081C355	20
4.0	.41	.57	1.17	81081B405	20	4.0	.50	.67	1.90	81081C405	20
4.5	.43	.60	1.17	81081B455	20	4.5	.54	.71	1.90	81081C455	20
5.0	.46	.63	1.17	81081B505	20	5.0	.57	.74	1.90	81081C505	20
6.0	.46	.61	1.45	81081B605	20	6.0	.64	.80	1.90	81081C605	20
8.0	.46	.63	1.70	81081B805	20	8.0	.75	.92	1.90	81081C805	20
10.0	.48	.64	1.90	81081B106	20	10.0	.85	1.01	1.90	81081C106	20
12.0	.53	.70	1.90	81081B126	20						
15.0	.60	.77	1.90	81081B156	20						
20.0	.71	.88	1.90	81081B206	20						

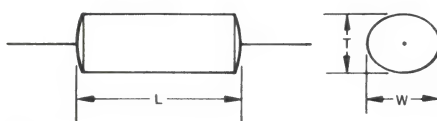
Combination Film

100 VOLT 200 VOLT

MFD	DIMENSIONS			CATALOG PART NUMBER	LEAD SIZE (AWG)	MFD	DIMENSIONS			CATALOG PART NUMBER	LEAD SIZE (AWG)	
	T ± .05"	W ± .05"	L ± .05"				T ± .05"	W ± .05"	L ± .05"			
.0010	.09	.18	.40	73081B102*	26	.0010	.09	.18	.40	73081C102*	26	
.0012	.09	.18	.40	73081B122*	26	.0012	.09	.18	.40	73081C122*	26	
.0015	.09	.18	.40	73081B152*	26	.0015	.09	.18	.40	73081C152*	26	
.0018	.09	.18	.40	73081B182*	26	.0018	.09	.18	.40	73081C182*	26	
.0022	.09	.18	.40	73081B222*	26	.0022	.09	.18	.40	73081C222*	26	
.0027	.09	.18	.40	73081B272*	26	.0027	.09	.18	.40	73081C272*	26	
.0033	.09	.18	.40	73081B332*	26	.0033	.09	.18	.40	73081C332*	26	
.0039	.09	.18	.40	73081B392*	26	.0039	.09	.18	.40	73081C392*	26	
.0047	.09	.18	.40	73081B472*	26	.0047	.09	.18	.40	73081C472*	26	
.0056	.09	.18	.40	73081B562*	26	.0056	.09	.18	.40	73081C562*	26	
.0068	.09	.18	.40	73081B682*	26	.0068	.09	.18	.40	73081C682*	26	
.0082	.09	.18	.40	73081B822*	26	.0082	.09	.18	.40	73081C822*	26	
.010	.09	.18	.40	73081B103	26	.010	.09	.18	.40	73081C103	26	
.012	.09	.18	.40	73081B123	26	.012	.09	.18	.40	73081C123	26	
.015	.09	.18	.40	73081B153	26	.015	.09	.18	.40	73081C153	26	
.018	.09	.18	.40	73081B183	26	.018	.09	.18	.40	73081C183	26	
.022	.09	.18	.40	73081B223	26	.022	.11	.20	.40	73081C223	26	
.027	.09	.18	.40	73081B273	26	.027	.09	.18	.40	73081C273	26	
.033	.09	.18	.40	73081B333	26	.033	.09	.18	.40	73081C333	26	
.039	.09	.19	.40	73081B393	26	.039	.10	.20	.53	73081C393	26	
.047	.10	.20	.40	73081B473	26	.047	.11	.21	.53	73081C473	26	
.056	.11	.21	.40	73081B563	26	.056	.13	.22	.53	73081C563	24	
.068	.13	.23	.40	73081B683	24	.068	.15	.24	.53	73081C683	24	
.082	.11	.20	.53	73081B823	24	.082	.16	.26	.53	73081C823	24	
.10	.13	.23	.53	73081B104	24	.10	.18	.28	.53	73081C104	24	
.12	.14	.24	.53	73081B124	24	.12	.21	.30	.53	73081C124	24	
.15	.16	.26	.53	73081B154	24	.15	.23	.33	.53	73081C154	24	
.18	.18	.28	.53	73081B184	24	.18	.21	.30	.68	73081C184	24	
.22	.22	.31	.53	73081B224	24	.22	.23	.33	.68	73081C224	24	
.27	.24	.34	.53	73081B274	24	.27	.24	.33	.78	73081C274	24	
.33	.27	.37	.53	73081B334	24	.33	.27	.36	.78	73081C334	24	
.39	.30	.40	.53	73081B394	22	.39	.30	.40	.78	73081C394	24	
.47	.34	.44	.53	73081B474	22	.47	.33	.43	.78	73081C474	22	
.56	.36	.46	.53	73081B564	22	.56	.37	.47	.78	73081C564	22	
.68	.25	.34	.78	73081B684	22	.68	.25	.42	1.17	73081C684	22	
.82	.28	.38	.78	73081B824	22	.82	.28	.45	1.17	73081C824	22	
1.0	.31	.41	.78	73081B105	22	1.0	.32	.49	1.17	73081C105	22	
1.2	.35	.45	.78	73081B125	22	1.2	.36	.52	1.17	73081C125	20	
1.5	.42	.52	.95	73081B155	22	1.5	.41	.58	1.17	73081C155	20	
1.8	.39	.48	.95	73081B185	22	1.8	.48	.62	1.17	73081C185	20	
2.0	.46	.56	1.17	73081B205	22	2.0	.46	.65	1.17	73081C205	20	
2.5	.33	.50	.78	73081B255	22	2.5	.35	.47	.64	1.45	73081C255	20
3.0	.37	.53	.78	73081B305	20	3.0	.37	.49	.63	1.70	73081C305	20
3.5	.41	.57	.78	73081B355	20	3.5	.41	.53	.67	1.90	73081C355	20
4.0	.44	.62	.78	73081B405	20	4.0	.44	.56	.66	1.90	73081C405	20
4.5	.47	.64	.78	73081B455	20	4.5	.47	.59	.70	1.90	73081C455	20
5.0	.50	.67	.78	73081B505	20	5.0	.50	.67	.73	1.90	73081C505	20
6.0	.56	.73	.78	73081B605	20	6.0	.60	.74	.78	1.90	73081C605	20
8.0	.67	.84	1.45	73081B805	20	8.0	.74	.90	.78	1.90	73081C805	20
10.0	.81	.97	1.70	73081B106	20	10.0	.84	1.00	.78	1.90	73081C106	20
12.0	.91	.107	1.90	73081B126	20							
15.0	.95	.111	1.90	73081B156	20							
18.0	.95	.111	1.90	73081B186	20							
20.0	.95	.111	1.90	73081B206	20							

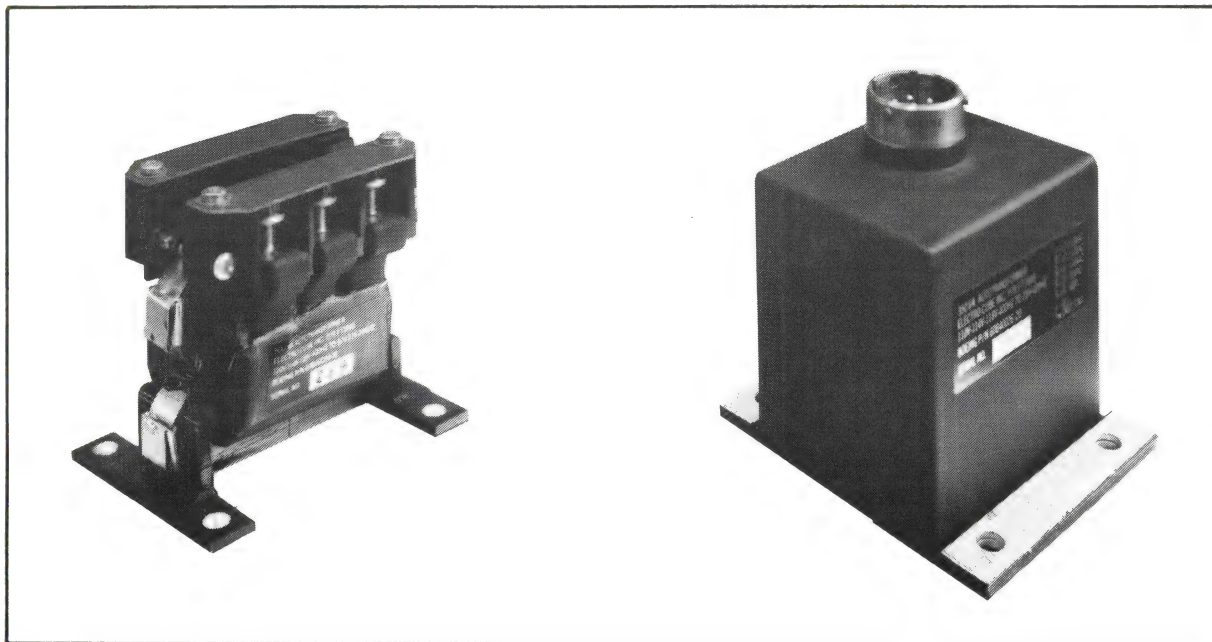
*Add suffix letter to part number for capacitance tolerance desired: $\pm 20\%$ = None $\pm 10\%$ = K $\pm 5\%$ = J $\pm 2\%$ = G $\pm 1\%$ = F.

**Higher voltages and other case styles (round wrap and fill, rectangular epoxy, round and rectangular metal hermetically sealed) are available.



LEAD LENGTH: 2.0" + .50"

Aluminum Foil Wound



Electro Cube aluminum foil wound transformers are available in the standard models listed on the reverse and also to customer requirements as isolation or auto transformers for frequencies from 25 cycles into the kilocycle range. Units may be single or multi-phase. Open frame, shell enclosure and hermetically sealed configurations can be furnished.

Advantages of these foil wound transformers over conventional wire wound units include:

- higher operating efficiency
- reduced weight
- improved thermal efficiency
- higher temperature operation
- improved regulation
- internal losses
- improved volume efficiency

The ability of a transformer to dissipate heat affects its maximum rating. Electro Cube foil wound coils have the ability to dissipate large amount of heat because there is a direct metallic path to each end of the coil from any point within the coil. Special end treatment of the coil including attachment to a heat sink, can make possible significantly reduced operating temperatures.

Wire wound coils, by comparison, are more difficult to cool. As a result of a limited heat path a lower coefficient of heat transfer and increased resistance due to heat and vice versa, the heat is greatest in that part of the coil least capable of dissipating it. Heat generated by conductors deep within the coil must pass through many thermal barriers of the insulation between the wires.

In addition to thermal efficiency, the materials in Electro Cube foil transformers permit use with higher operating temperatures than are possible with wire coils with equivalent

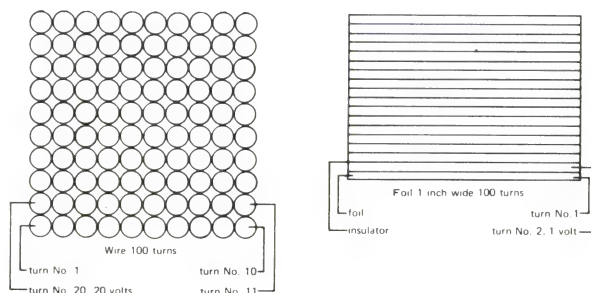


Figure 1. Typical coil sections with 100 volts excitation.

lent insulation ratings. This also contributes to reduced weight and volume.

Figure 1 shows the relative difference in volume required for a 100 turn wire coil and an equivalent foil coil, and the relative use of space for insulation and conductors. It also shows voltage stress and insulation requirements for the two configurations. At 1 volt per turn there would be 20 volts between the 20th and first turn of the wire coil. When the top layer is finished, the last turn may lay against one of the first, resulting in a voltage difference of up to 100 volts. The foil coil never has more than 1 volt between any two conductors, or a 100 to 1 advantage over the wire coil, in this example.

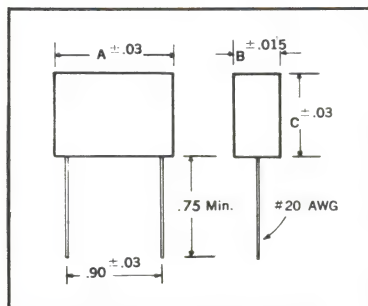
The physical arrangement of the foil windings promotes a lower leakage reactance or power loss in the transformer, which contributes to efficiency and regulation. Together with the lower I^2R loss of the windings, this allows the use of fewer circular mils of conductor area to meet required efficiency and regulation requirements.



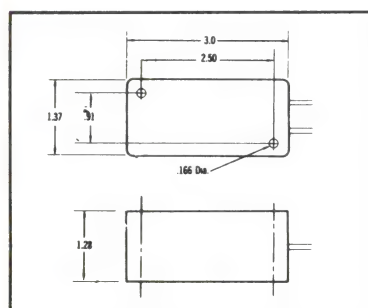
UL Recognized



RC Networks

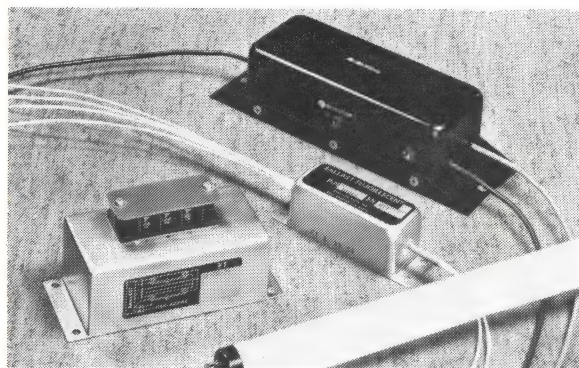


Capacity MFD	Resistance Ohms ±10%	Rated Voltage	Peak Pulse Voltage	Dimensions A in.	B in.	C in.	Electro Cube Part Number
0.5 ± 10%	22	200 VDC	300 V	1.00	.38	.63	RG 1780 — 1
0.5 ± 10%	33		300 V	1.00	.38	.63	RG 1780 — 2
0.5 ± 10%	47	OR	300 V	1.00	.38	.63	RG 1780 — 3
1.0 ± 10%	22		300 V	1.00	.50	.75	RG 1781 — 1
1.0 ± 10%	33	125 VAC	300 V	1.00	.50	.75	RG 1781 — 2
1.0 ± 10%	47		300 V	1.00	.50	.75	RG 1781 — 3
0.1 ± 20%	22	600 VDC	900 V	1.00	.38	.63	RG 1782 — 1
0.1 ± 20%	33		900 V	1.00	.38	.63	RG 1782 — 2
0.1 ± 20%	47	OR	900 V	1.00	.38	.63	RG 1782 — 3
0.25 ± 20%	22		900 V	1.00	.50	.75	RG 1783 — 1
0.25 ± 20%	33	250 VAC	900 V	1.00	.50	.75	RG 1783 — 2
0.25 ± 20%	47		900 V	1.00	.50	.75	RG 1783 — 3
0.5 ± 10%	22	250 VAC	900 V	1.25	.58	.83	RG 1784 — 1
0.5 ± 10%	33		900 V	1.25	.58	.83	RG 1784 — 2
0.5 ± 10%	47		900 V	1.25	.58	.83	RG 1784 — 3



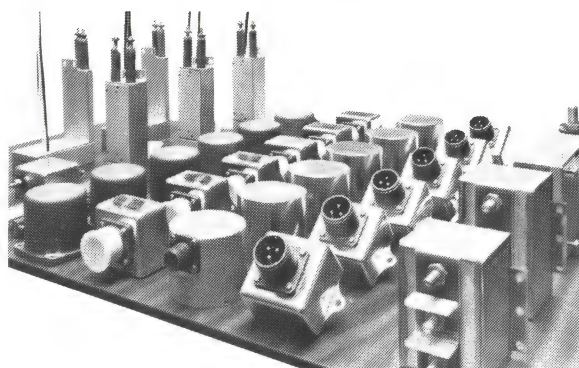
Part #	Resistance Ohms	Tolerance %	Power Watts	Capacity MFD	Tolerance %	VDC Volts	VAC Volts	Thyrector Part #	Lead Length Inches	Circuit #
RG 1676-1	100	10	10	1.0	10	1000	480	N/A	24	1
-148	100	10	10	1.0	10	1000	480	N/A	48	1
-2	100	10	10	.5	10	1000	480	N/A	24	1
-3	10	10	2	1.0	10	600	250	N/A	25	1
-10	220	10	5	2.0	10	600	250	N/A	25	1
-12	220	10	2	.5	10	1000	480	N/A	24	1
-13	220	10	1	.47	10	1000	480	N/A	24	1
-1848	220	10	5	.47	10	1000	480	N/A	48	1
-19	220	10	2	1.0	10	400	120	N/A	24	1
-20	100	10	2	2.0	20	600	250	N/A	18	1
-21	10	10	5	1.0	10	1000	480	N/A	24	1

Ballasts

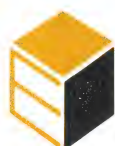


Electrocube has designed and produced a wide variety of fluorescent ballasts for airborne and ground systems installation, as well as selected commercial applications where size and weight are considerations. These lightweight units are offered in 60 Hz and 400 Hz versions, for operation on DC and to 15 KHz, for fixed or dimmable circuits. Either leading or lagging power factors may be specified, and burnout protection can be provided against tube rectification. For cold weather applications, ballasts have been designed for normal operation in temperatures to -10°C .

Filters



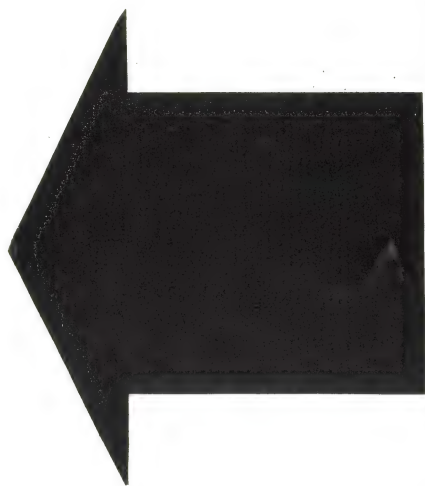
Electrocube has developed literally thousands of EMI filters, to meet military, aerospace and commercial applications. Versions have been designed with current carrying capacities from 0.1 to 500 amps, voltages to 5000 VDC and 600 VAC, and for DC to 1000 Hz and intermittent or continuous duty. Single and multi-circuit configurations are also offered, including L, Pi (also with feed-through capacitors) and T. Models include low pass, high reject, noise, interstage and line, screen room, and heavy duty industrial filters.



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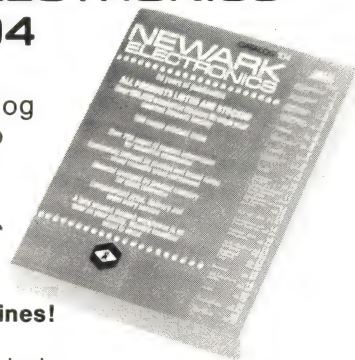
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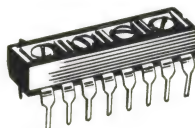
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Flip flop provides long delay

Haresh Shah

Bunting Steri System, Bridgeport, CT

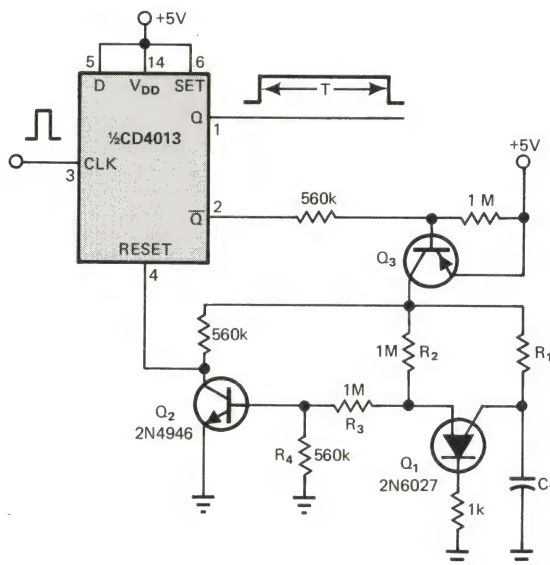
You can extend the delay of a D flip flop with the 3-transistor circuit shown in the figure. The unijunction transistor (Q_1) remains OFF until the voltage across C_1 exceeds its threshold voltage. This hold-off time can be determined from

$$T = R_1 C_1 \ln(1/(1 - (V_T + 0.6)/V_{DD}))$$

and ranges from a few milliseconds to a few minutes.

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Delay circuitry stretches an output pulse to a length dependent on the charge rate of C_1 through R_1 . For the component values shown, the pulse period T is $0.8R_1C_1$.

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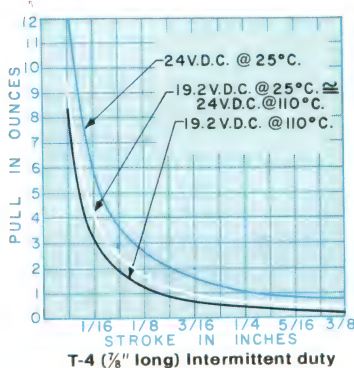
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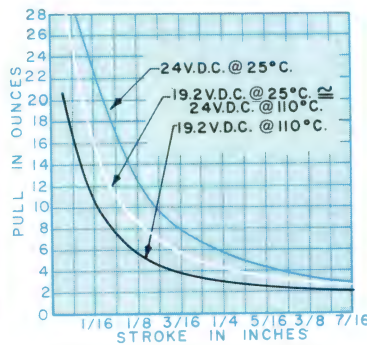
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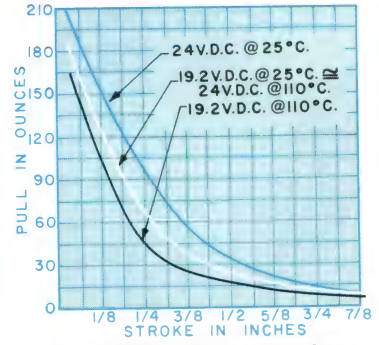
Check these curves.



T-4 (1/8" long) Intermittent duty



T-8 (1 1/8" long) Continuous Duty



T-12 (1 1/2" long) Intermittent Duty

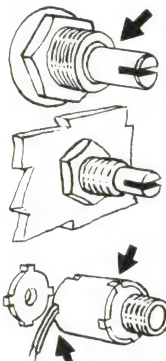
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Once you put a Guardian Tubular in your product...forget it. Typical mechanical life is 20 million. That's probably longer than your product's life expectancy...due primarily to the unique Valox® 420 molded bobbin.

Variations and specials? Guardian's got 'em. Any DC voltage from 6 to 240. Push type or pull type operation. Return springs, silencers, termination variations, special mountings... you name it and we'll deliver it with the high quality craftsmanship and low prices that have made Guardian Number 1 in Solenoids—and that keeps us here on top.

Let the Guardian Angel reveal all the pull charts and curves in full size. Send for your free copy of our 72 page catalog.



This mark indicates recognition under the component program of Underwriters Laboratories, Inc.



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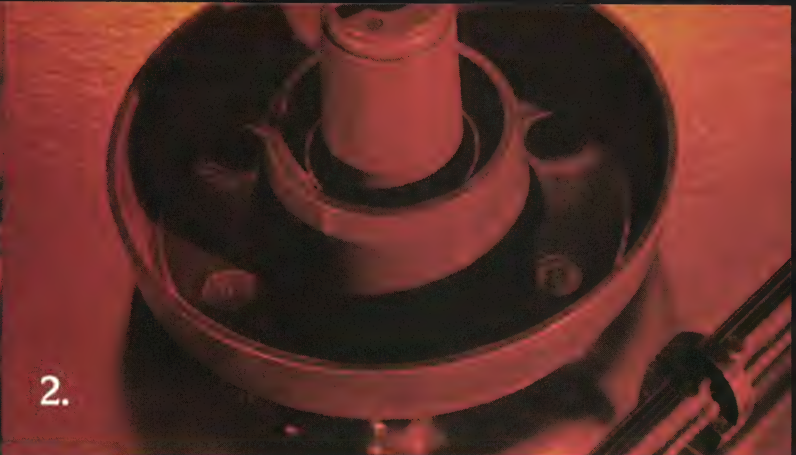
See us at Booth # 1310
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For more information, Circle No 74



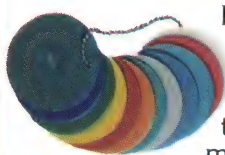
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2.

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Ryton engineering plastics are available in 5 standard colors and an unlimited number of custom variations. And, as always, Ryton technicians stand ready to help you make the most out of your Ryton applications. For quick action from the Ryton Sales Engineer nearest you call our Phillips Engineering Plastics Office toll free ... 800 231-3630 (In Texas 800 392-3716).

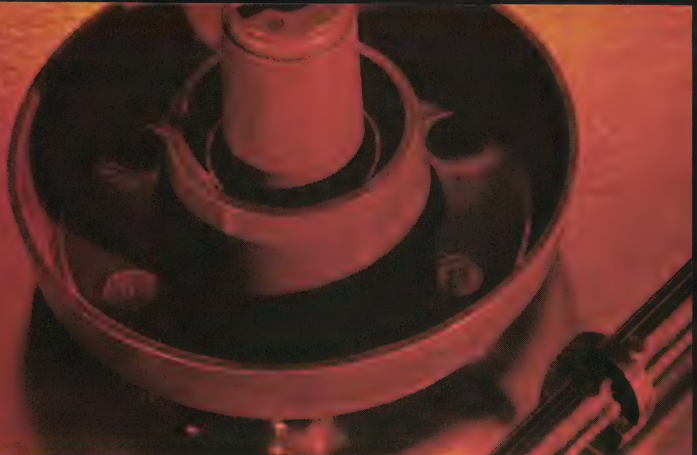
Ryton® engineering plastics perform.

Phillips also produces K-Resin® butadiene styrene polymers and Marlex® polyolefin resins. Call toll free 800 231-1212 (In Texas 800 392-2078).

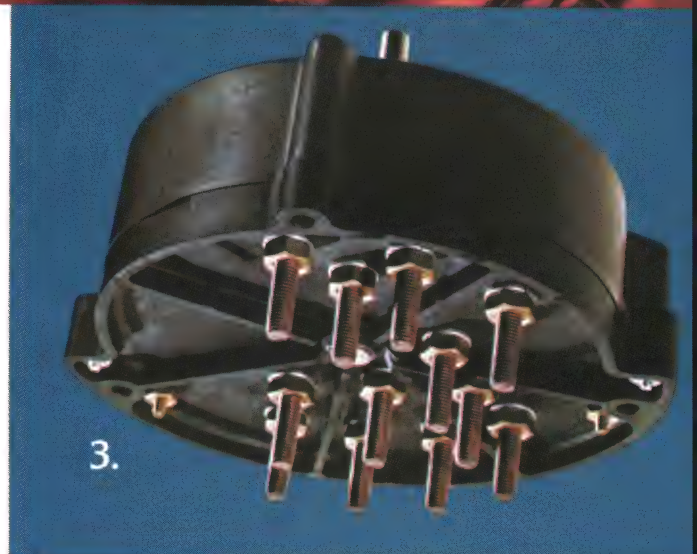
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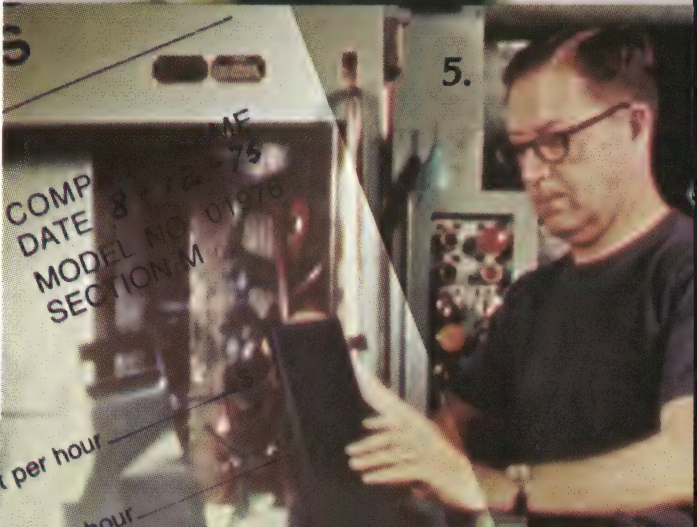
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5.



Feature Products

Electronic load handles 300A, features no-guess digital readout

Power supplies are getting bigger and bigger, and whether you build them or buy them, you must also be able to test them. Lectra-Load II meets this need; it's programmable, dissipates up to 1250W, specs a 0 to 300A constant-current capability and a 0.01 to 100 Ω constant-resistance range, and accepts inputs ranging from 1.5 to 50V dc.

Unlike its competitors, the instrument sports a 4-digit readout and a *true* short-circuit test, controlled by a pushbutton. Its flexibility is further enhanced by a built-in pulse generator that can simulate dynamic loads. And for direct, constant sampling of these tests, the unit provides a front-panel 1-mV/A scope output.

Varied uses

If you're not familiar with electronic loads, you might not appreciate the Lectra-Load II's full capabilities. So consider the following potential applications of the device:

- In its constant-current mode, you can connect it in series with a constant-voltage dc power supply to form a variable constant-current source.
- It can test capacitor banks and batteries by acting as a constant-current discharge; it also tests dc voltage regulators.



Programmable from front-panel controls or remotely via resistance or voltage inputs (IEEE-488 capability is optional), the portable Lectra-Load II operates over 0 to 40°C. Its dynamic loading capability permits switching between two current levels, and its built-in pulse generator provides both amplitude and duty-factor adjustment over a 1- to 1000-Hz range.

- Because its voltage range extends down to 1.5V, it can test ECL power supplies.
- In its constant-resistance mode, the wide range frees you from the need to stock power rheostats among your test components.
- By using its built-in pulse generator, you can create many useful tests. For example, with duty factor set at 100%, you can program the unit to exercise a power supply at three levels—no load plus two preprogrammed values.

Human engineering

To make the Lectra-Load II easier to operate, designers engineered its front

panel with well-spaced vernier controls and smooth push-push mode and range switches. They also added a built-in bale that tilts the instrument to the desired viewing angle.

Inside the electronic load's 5×10×16-in. case, all-copper heat sinks and bus bars attest to quality construction. Service problems are further minimized by the use of plug-in-type pc boards and cables, socket-mounted heat-dissipating elements and hermetically sealed semiconductors. Two 4-in. cooling fans eliminate hot spots. \$1100; available in August.

Power/Mate Corp, 514 S River St, Hackensack, NJ 07601. Phone (201) 343-6294. Circle No 455

Centigrid II: Never before a relay this sensitive at this size



We told you that our Centigrid® was the ultimate sub-miniature relay — and it is. Centigrid II is not a replacement, but a companion developed for applications that demand ultra-small size *plus* ultra-high sensitivity. Centigrid II dissipates 65% less power than the .150 grid relay, and 75% less than the 1/2 crystal can. And it still features .100" grid spaced pinout for optimum pc board layouts and occupies only .14 sq. in. of board space.

Like the TO-5, the Centigrid II makes an ideal subminiature RF switch, providing high isolation and low insertion loss up through UHF frequencies. And the low coil power requirement means extended battery life for hand-held transceivers.

Centigrid II meets all requirements of MIL-R-39016, and is available with internal diode suppression. Call or write us today for complete specification data.

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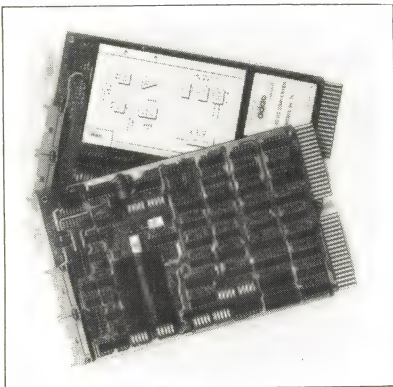
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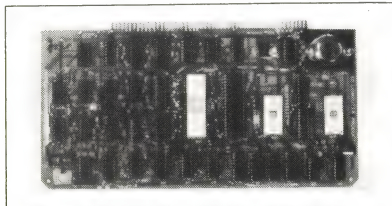
New Products

COMPUTER-SYSTEM SUBASSEMBLIES



I/O CARDS. These two dual-width boards furnish I/O capabilities to DEC LSI-11, LSI-11/2 and PDP-11/03 μ Cs, as well as the manufacturer's Series 1000 and 2000 systems. One of the boards, the Model 1750 asynchronous serial-line I/O card, contains sockets for 512 \times 16 bits of PROM. Each of this dual-port board's I/O channels performs serial to parallel (and vice versa) conversion in 5-, 6-, 7- or 8-bit format.

The other board, the Model 1014 A/D converter, features 14-bit resolution and a 10-kHz throughput rate. This unit allows random- or sequential-mode access, vector addressing, and selection of full-scale ranges and register addressing. You can increase its 16-channel capacity to 64 channels with a Model 1012-EX expander board. Model 1750, \$395; Model 1014, \$1195. Delivery, 30 days ARO. **ADAC Corp.**, 70 Tower Office Park, Woburn, MA 01801. Phone (617) 935-6668. **Circle No 166**

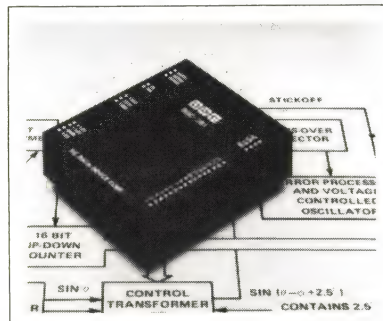


VIDEO-DISPLAY BOARD. The Z80 μ P-based VDB-8024 offers 80-character \times 24-line display (7 \times 10-dot character matrix), composite video output (in addition to separate TTL-level sync and video outputs), 2k bytes of RAM and an I/O-mapped interface. Display features include full cursor control, forward and reverse scrolling, variable-speed display rate and enhancements such as blinking

and underlining. \$499 (\$349, kit). **SD Systems**, Box 28810, Dallas, TX 75228. Phone (214) 271-4667. **Circle No 167**

ANALOG I/O BOARDS. Compatible with PDP-11 Unibus systems, the DT1711 Series of 1-card analog-I/O and input systems offers four hex-height models. Standard features of units in this family include a channel capacity of up to 64 analog inputs and a choice of high- or low-level signal capability with 12-bit A/D conversion. These boards can also perform logic-controlled 3-axis point plotting via high-current outputs from two 12-bit DACs and an on-board Z-axis pulse generator. From \$1240. **Data Translation Inc.**, 4 Strathmore Rd, Natick, MA 01760. Phone (617) 655-5300. **Circle No 168**

PRINTER INTERFACE. Containing two separate interfaces, the PRI card handles either dot-matrix or daisy-wheel printers. One interface utilizes the "Centronics parallel" convention for dot-matrix operation, the other employs the "daisy-wheel parallel" convention and includes ribbon-lift and ribbon-lowering circuitry. \$195. **Cromemco Inc.**, 280 Bernardo Ave, Mt View, CA 94043. Phone (415) 964-7400. **Circle No 169**



S/D CONVERTER MODULE. Featuring internal transformer isolation, the SDC-361 synchro-to-digital converter module operates over a 47-to-1000-Hz range. This 2-speed (1:36 ratio) converter provides accuracy to within 20 seconds of angle and accommodates all standard synchro and resolver input formats. Tracking rates are 1000°/sec for 400 Hz and 250°/sec for 60 Hz. \$695. **ILC Data Device Corp.**, Airport International Plaza, Bohemia, NY 11716. Phone (516) 567-5600. **Circle No 170**



Cahners Publishing Company

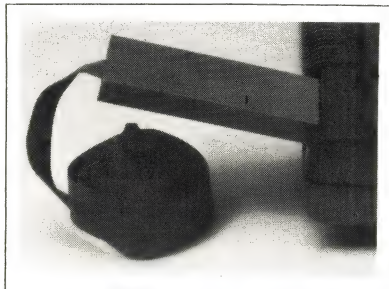
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New Products



PRINTER INTERFACE. Plugging directly into the back of a TRS-80 computer keyboard, the Print Module eliminates the need for an expansion interface when driving printers such as Centronics (P1, 779, 703), Telpar and Axiom models. This parallel line-printer interface is compatible with line-print commands in Level II BASIC. \$99.95. **American Micro Products**, 6550 Tarnef, MS 11, Houston, TX

77074. Phone (713) 777-2759.

Circle No 171

UNIBUS I/O BOARD. Acting as a general-purpose interface, the DUAL I/O board provides the logic for program-controlled parallel transfers of 16-bit data between two external devices and a Unibus system. The quad-height unit is the hardware and software equivalent of two DR11-C interfaces. \$900. **Able Computer Technology Inc.**, Box 18162, Irvine, CA 92714. Phone (714) 979-7030.

Circle No 172

Micro upgrades its *new* ELECTRONIC READ/WRITE TAPE SYSTEM.

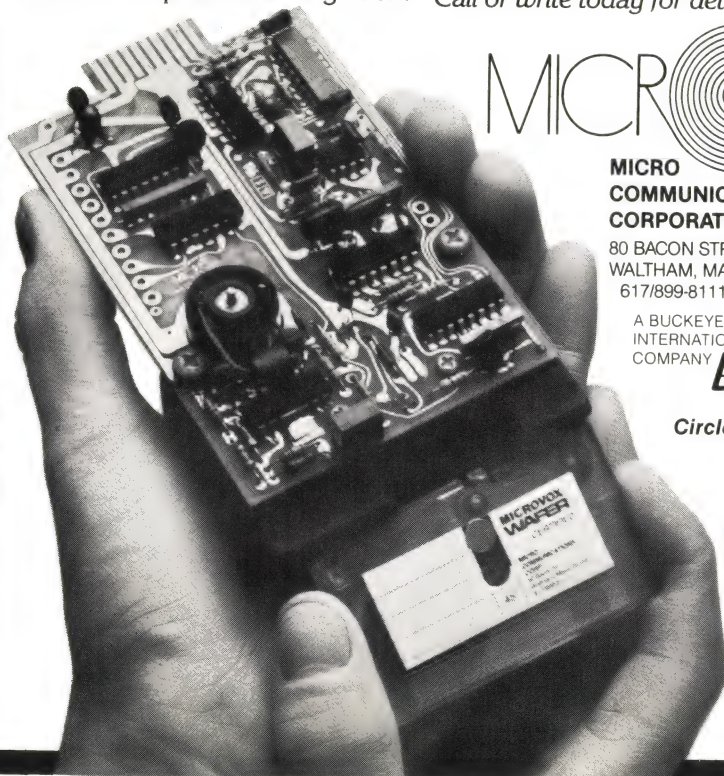
MICRO COMMUNICATIONS has been delivering its new ELECTRONIC READ/WRITE Tape Transport System to a number of customers in such application areas as Program Loading, Data Logging, Point of Sale and Personal / Small Computers.

Since introduction, Micro has upgraded the capability of the system to include such features as a 4800 baud transfer rate and *double density* (3200 fci). Mainly based upon the size and weight of the system (less than 6" in length; less than 6 ounces in weight), the system is a natural for microprocessor integration.

The READ/WRITE System includes such features as: TTL and CMOS compatability, START/STOP TIME of 30/40 milliseconds, a block construction of *die cast aluminum*, a *read/write* speed of 3 ips and a fast forward speed of 6 ips and a data capacity of 120K bytes (using a 50' wafer cartridge).

In OEM quantities, the READ/WRITE System is \$69.00. Delivery is two weeks ARO. Micro supplies mechanical transports at \$25.00 per unit in 1000 unit quantities. Data sheets and system documentation are available upon request.

Call or write today for details.



MICRO COMMUNICATIONS CORPORATION

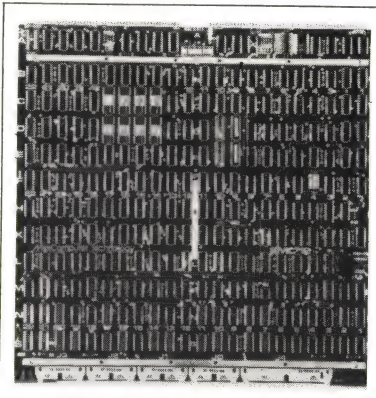
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Circle No 78

DAC BOARD FOR LSI-11. Residing on a half-quad-size board, the ST-LSI-DA4 4-channel DAC interfaces with LSI-11 μ Cs. Jumper-selectable addressing allows you to cascade any number of boards. These 12-bit units offer 4- μ sec settling time, $\pm 1/2$ -LSB max nonlinearity and a choice of four full-scale output-voltage ranges: 0 to +5, 0 to +10, -5 to +5 and -10 to +10V. \$535; \$475 without dc/dc converter. **Datel Systems Inc.**, 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 828-8000. **Circle No 173**

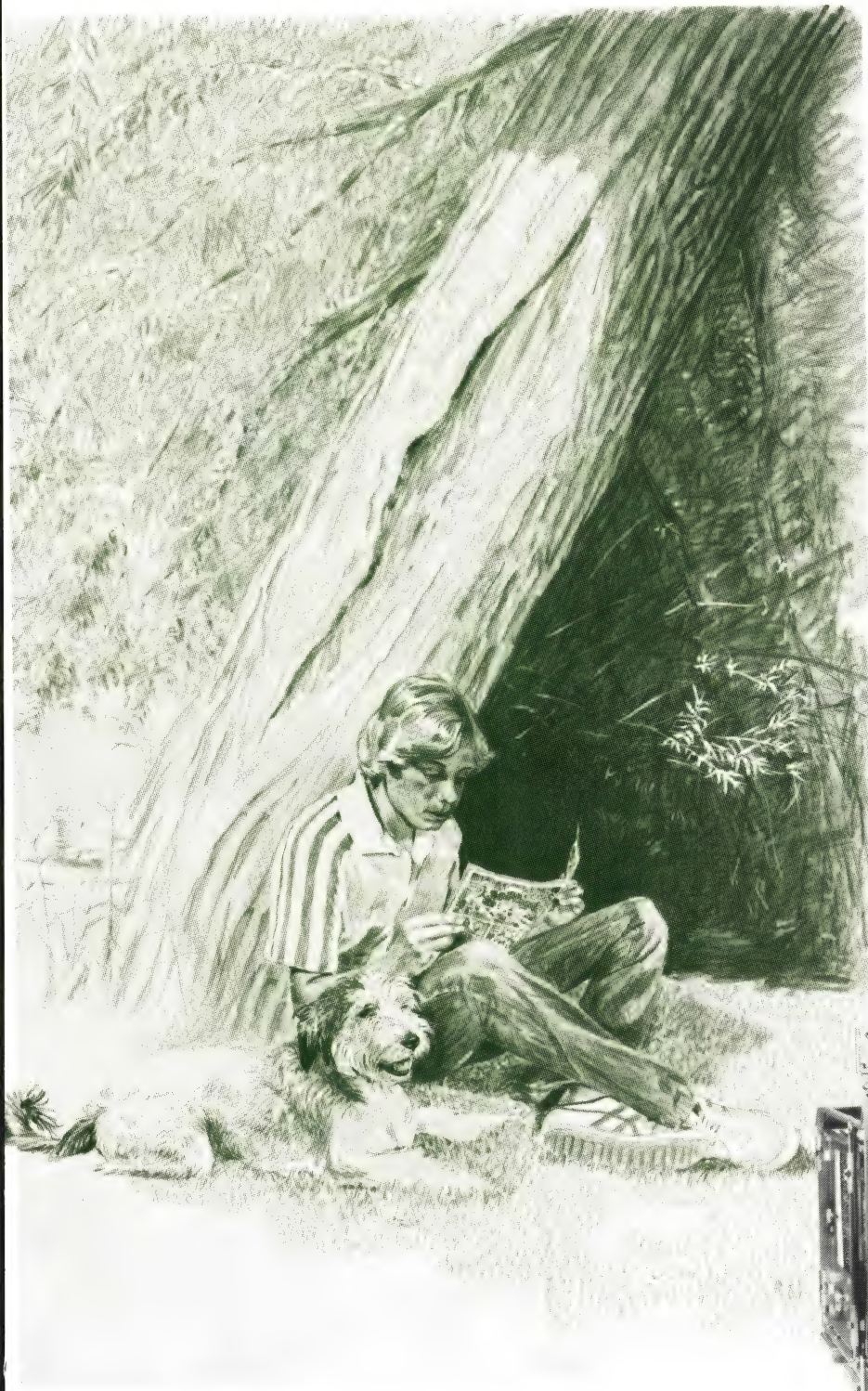


DISC CONTROLLER. With a transfer rate up to 1.2M bytes/sec, the SM12 interfaces Data General minicomputers to as many as four storage-module disc drives in any mix of capacities up to 1200M bytes. Two computers with these controllers can share dual-ported drives. Dual, full-sector RAM buffers allow single-command contiguous-sector transfers up to 64k words. \$3580. Delivery, 45 days ARO. **Minicomputer Technology**, 2470 Embarcadero Way, Palo Alto, CA 94303. Phone (415) 321-7400.

Circle No 174

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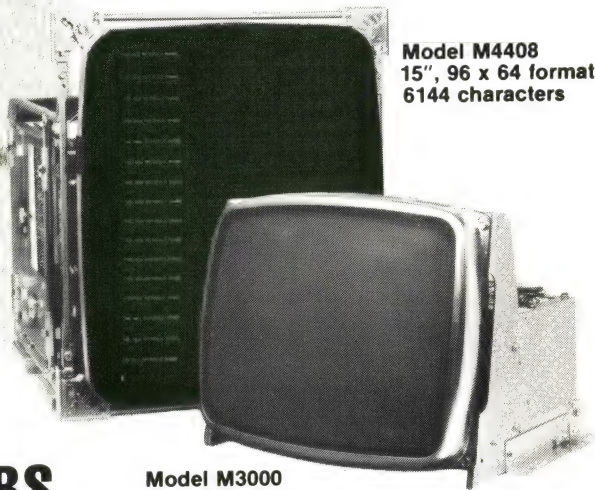
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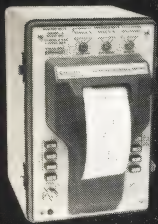
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Now—Analyze, Monitor, & Record Disturbances on both the AC Line and 2 DC Levels simultaneously



Fantastic new version of the original Series 606 micro-programmed line-disturbance monitor, the Series 616 senses impulses, sags/surges, and slow-average variations in one AC and two DC levels, simultaneously. Internal processor prints out all data on each type of disturbance, with time signature; also summaries, daily and on demand. Performs all tests required to verify static and transient behavior of power-supply systems, especially UPS, at the factory and on-site.

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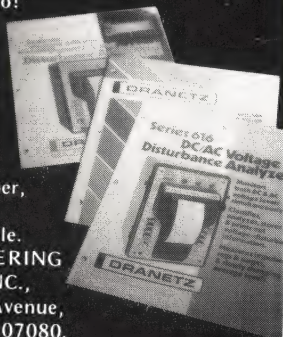
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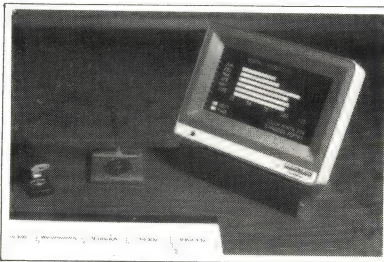


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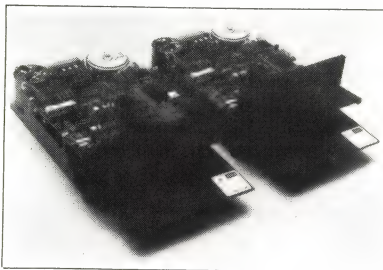
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New Products

COMPUTERS & PERIPHERALS



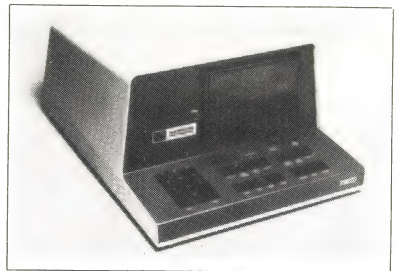
TOUCH PANEL. Communicating at 300 to 19,200 baud over an RS-232 interface, Vuepoint serves as a direct replacement for a CRT terminal. Only 2.5 in. thick, the unit's 12-line×40-character panel accepts touch input. Wall-mount, rack-mount, printer and keyboard options configure the panel for a variety of applications. \$3500. **General Digital Corp.**, 700 Burnside Ave, East Hartford, CT 06108. Phone (203) 289-7391. **Circle No 211**



MINI-FLOPPY DRIVE. Offering 40-track capacity in a small package, Model 6106 5.25-in. floppy drive furnishes track-to-track access time of 12 msec. The drive operates in both FM and MFM recording modes, providing up to 250k bytes (unformatted) storage on one side of a diskette. \$450; \$225 (500). **BASF Systems**, Crosby Dr, Bedford, MA 01730. Phone (617) 271-4064. **Circle No 212**

MODULAR TERMINALS. By combining the separately packaged display screens, keyboards, printers, magnetic card readers and memory subsystems included in BMT Series electronic terminals, you can tailor them to specific applications. Each terminal furnishes its own intelligence, eliminating the need for separate terminal controllers. From \$2500. **Burroughs Corp.**, Box 418, Detroit, MI 48232. Phone (313) 972-7267. **Circle No 213**

FLOPPY-DISC EXECUTIVE. Suitable for most popular 6800 systems, INDEX (interrupt-driven executive) services the console and I/O devices by interrupt requests rather than polling. You can write your own utility commands and driver routines to expand the versatility of the operating system. The software comes on two mini diskettes. \$99.95. **Percom Data Company**, 318 Barnes, Garland, TX 75042. Phone (214) 272-3421. **Circle No 214**

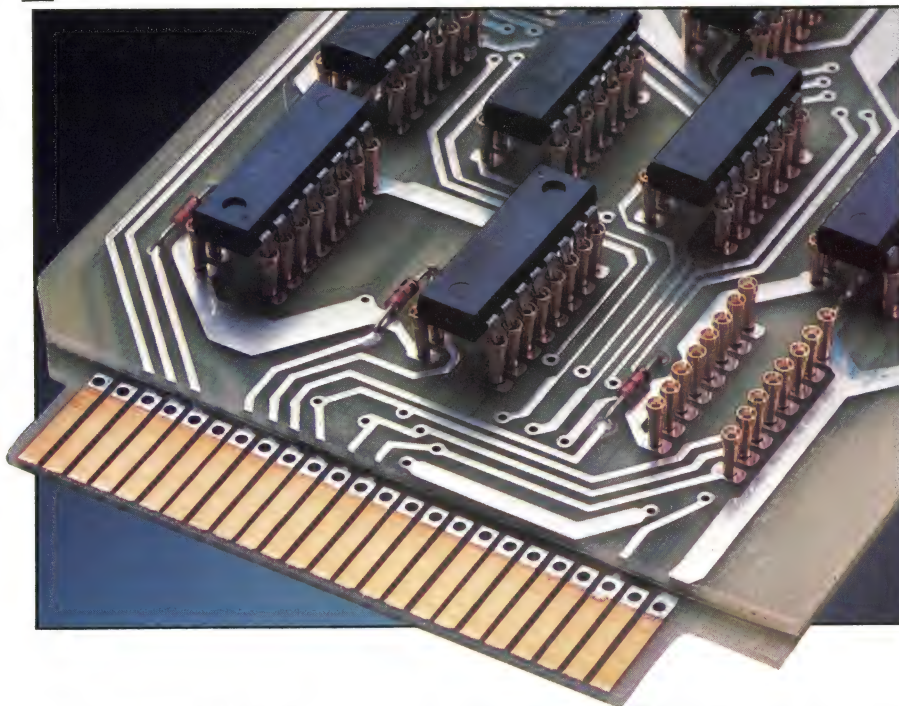


COMMUNICATIONS DISC. Designed to efficiently replace paper-tape, cassette or magnetic-tape units, Model AJ 460 diskette system operates at higher transmission rates than those devices and furnishes over 204k of storage. You can record data in binary, which allows the system to be transparent to control characters, or in packed mode for maximum storage efficiency. \$1995. **Anderson Jacobson Inc.**, 521 Charcot Ave, San Jose, CA 95131. Phone (408) 263-8520. **Circle No 215**

MODEM MULTIPLIER. MM-4 is designed to replace multiple modems interfaced to individual terminals in polled communications systems. The multiplier supports four terminals and each terminal can be located up to 50 ft from the unit. The units can also be linked to support more than four terminals. \$450. **Wizard Associates**, 1019 S Noel, Wheeling, IL 60090. Phone (312) 541-6803. **Circle No 216**

CRT TERMINAL. Offering switch-selectable software compatibility with four leading terminals, Act-V provides a separate numeric keypad, and software-selectable screen formats of 80×24 or 48×39. \$865. **Micro-Term Inc.**, 1314 Hanley Industrial Ct, St Louis, MO 63144. Phone (314) 968-8151. **Circle No 217**

Expanding the parameters of press-fit technology



New press-fit I.C. socket offers lower cost, higher density and cooler operation.

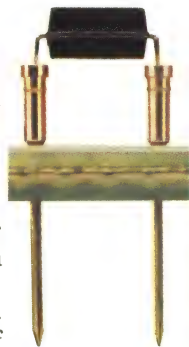
Low Cost

Using a conventional precision screw machine contact, press-fit into the circuit board, this new socket is a major improvement over time-proven packaging methods. This innovative conversion to press-fit techniques greatly increases cost effectiveness by reducing need for external wiring and the elimination of soldering.

Characteristics of the new socket allow us to selectively plate a portion of the tails with significant savings in gold plating.

High Density—Greater Design Freedom
The new socket stands rather high on the board (.190")—but with good reason.

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complex and expensive multilayered boards.

Cooler Operation

Since the socket stands up off the board, air flow aids in heat dissipation giving you much cooler operating temperatures. This is especially significant with higher pin count IC's.

Oriented Contact — both clip and contact tail.

Clip is so oriented that the four contact tines are in perfect alignment with the IC lead. Each tail is oriented square and parallel with the others to accept a mating connector when desired. An Elfab exclusive!

For additional information contact:



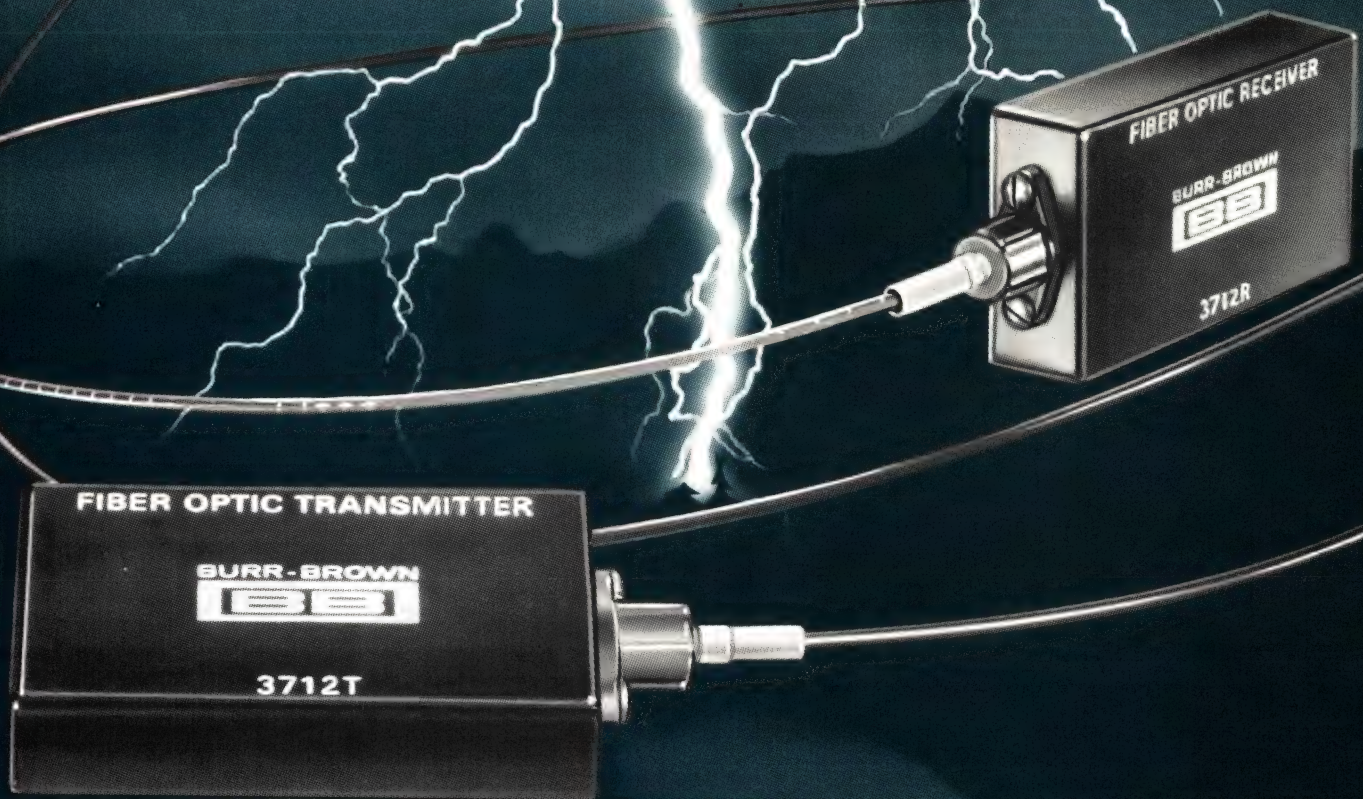
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This fiber optic data link offers the lowest cost alternative to achieve total electrical isolation and noise immunity. 3712T transmitter (TTL In/Light Out) and 3712R receiver (Light In/TTL Out), coupled by fiber optic cable, form a simplex data link. You're assured of reliable, error-free 20k bit data transmission through hostile, noisy environments.

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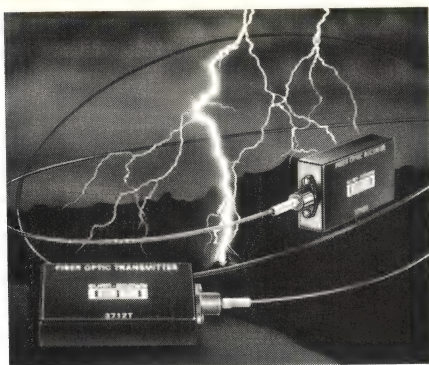
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New Products

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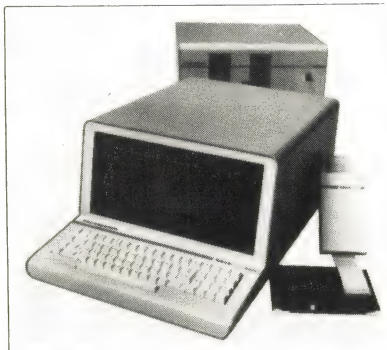
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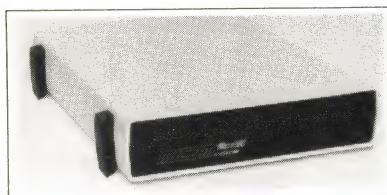
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For more information, Circle No 81

EDN APRIL 5, 1979



DEVELOPMENT SYSTEM. Providing the necessary tools for developing 8080-, 8085-, 6800-, 6802- or Z80-based products, the AMDS system furnishes real-time, in-circuit emulation up to 5 MHz. A 48-channel logic analyzer provides three hardware-break registers and a 256-state trace buffer. Software includes a screen-based editor and macro assembler. \$16,500, with choice of CPU. **Future-data Computer Corp.**, 11205 S La Cienega Blvd, Los Angeles, CA 90045. Phone (213) 641-7700. **Circle No 218**



ERROR CONTROLLER. Eliminating the risk of undetected transmission errors by providing retransmission on error, Micro500 suits data communications over dial-up or dedicated lines at speeds up to 9600 bps. The unit also furnishes asynchronous to synchronous conversion. \$895. Delivery, 45 days ARO. **Micom Systems Inc.**, 9551 Irondale Ave, Chatsworth, CA 91311. Phone (213) 882-6890. **Circle No 219**

PRINT MECHANISM. Model AP-20M provides up to 20 columns of nonimpact thermal printing. The 5x7 alphanumeric characters output at 2.5 lines per sec, and the unit's fixed-head design requires only one moving part—the paper-roll drive. \$275. **Gulton Industries Inc.**, Gulton Industrial Park, East Greenwich, RI 02818. Phone (401) 884-6800. **Circle No 220**

MULTIUSER MICRO. Based on an 8085A computer, Microstar adds a floppy-disc operating system with interactive BASIC, multiuser and multitasking capability and a report writer to furnish complete software support. File access methods supported include direct, sequential and index sequential (ISAM). **Micro V Corp.**, 17777 S E Main St, Irvine, CA 92714. Phone (714) 957-1517.

Circle No 221



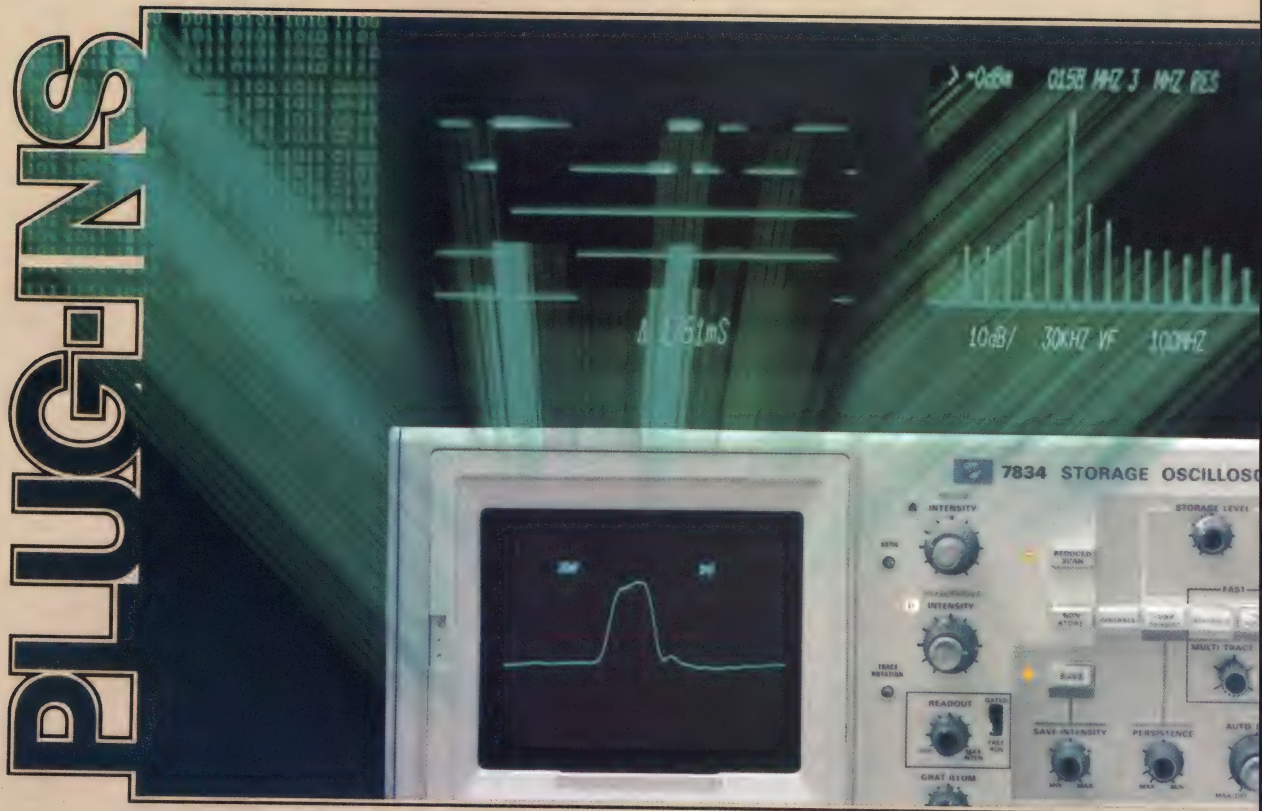
μ C SYSTEM. Configured around the Z80 μ P and a 12-in. Mindless terminal, System B utilizes both the manufacturer's disc operating system and CP/M. The system incorporates a 48k dynamic-RAM board; a Flashwriter video board displays 80x24 characters in an 8x10 matrix. \$4750. **Vector Graphic Inc.**, 31364 Via Colinas, Westlake Village, CA 91361. Phone (213) 991-2302. **Circle No 222**

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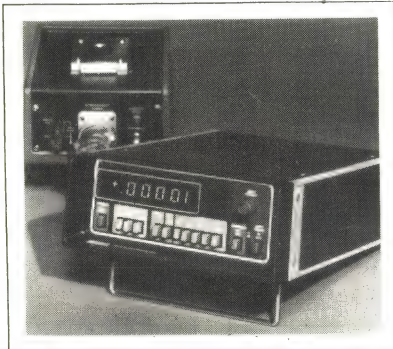
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New Products

INSTRUMENTATION & POWER SOURCES

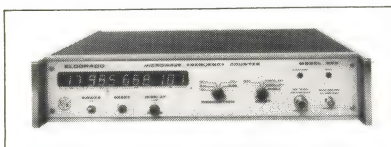


10⁻¹⁷A ELECTROMETER. In Model 642, MOSFET technology enables you to make measurements to 60 electrons/sec. Resolution approaches 0.005% of the input signal, so one range covers 200× the span of an equivalent analog instrument's—one range thus replaces six analog ranges.

The instrument provides direct readings of voltage, current or charge, spanning 10 μ V to 10V (10¹⁶ Ω input resistance), 10⁻¹³ to 10⁻⁷A FS (4-1/2-digit resolution) and 10⁻¹¹ coulombs (0.1, 1 or 10 ranges).

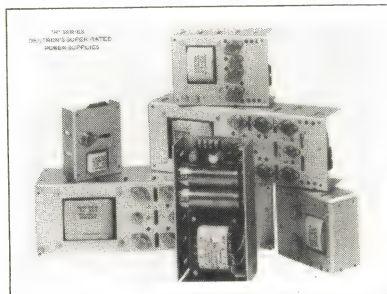
Innovations in the electrometer's design include a drift-compensated input stage; a lead(PB)-free input-terminal that minimizes surrounding air volume and thus reduces ionization; elimination of the need for switching devices with OFF resistances in the order of 10¹⁷ Ω ; and minimized-insulation contact points, guarded and made of sapphire to reduce their contribution to leakage currents.

Analog inputs permit recording of large signals and allow high-gain observation of low signals. Dessicant paper, BCD output, BNC input connector, an air-line input connector, a test box and a battery adapter (to allow external 12V powering) are available as accessories. \$3395. Delivery, 60 to 90 days ARO. **Keithley Instruments Inc.**, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. **Circle No 175**

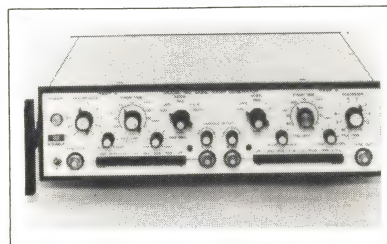


μ WAVE FREQUENCY COUNTER. Model 990 performs completely auto-

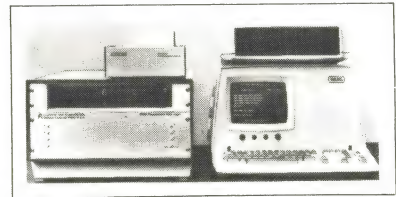
matic measurements under μ P control. A frequency-only device, it utilizes automatic heterodyning to cover from 20 Hz to 18 GHz in two ranges. Sensitivity specs at -25 dBm; overload at +25 dBm. Options provide -30-dBm sensitivity, 26-GHz response, GPIB (IEEE 488-1975) interface and 2W input protection. \$3800. **Eldorado Instruments Co.**, 2945 Estand Way, Pleasant Hill, CA 94523. Phone (415) 682-2100. **Circle No 176**



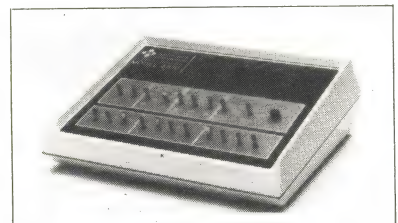
OPEN FRAMES. Claimed to deliver 25% more output than competitive units with the same case size, R Series supplies feature socketed semis and protection against reversed voltage or loss of sense. Forty two single-output models span 5 to 24V at 1.5 to 33.7A. All have a shielded split primary, 0.1% regulation and 1.5-mV rms noise. OVP comes as an option. From \$37. **Deltron Inc.**, Wissahickon Ave, North Wales, PA 19454. Phone (215) 699-9261. **Circle No 177**



DUAL RAMP GENERATOR. Model 180 effectively combines dual-ramp raster and delay generation. Its two complete 1- μ sec to 1000-sec ramp generators (independently operable) can be synchronized for 1:1, 2:1 and 4:1 interlace. Rasters can easily be generated by using the unit's position and size controls, reverse sweeps, single-shot frames and fields, composite blanking pulses and 2:1 and 4:1 vertical sweeps for interlace. \$995. **Exact Electronics Inc.**, Box 347, Tillamook, OR 97141. Phone (503) 842-8441. **Circle No 178**



DAS. Included in Model 7251B are a BASIC-language computer with CRT, printer and mini-floppy disc; 8k of RAM (in addition to 42k of BASIC ROM); a scanner/mainframe with capacity for 14 I/O cards; a 4-1/2-digit DVM and a 10-channel low-level MUX. You can display bar charts and quasi-graphics on the CRT. Little or no programming experience is required of system users. \$12,700, including the computer. **FI Electronics**, 968 Piner Rd, Santa Rosa, CA 95401. Phone (707) 527-0410. **Circle No 179**



BUS-FAULT ANALYZER. Using the portable Model 4810 you can view or control IEEE-488-bus data, handshake and control lines. The analyzer acts as a manual bus driver, controlled either from front-panel switches or the switch-programmed memory. For fault analysis, an internal memory permits review of up to 100 characters of bus transmissions; a memory loop bypasses unused memory space and repeats only the programmed segment. \$1595. **ICS Electronics Corp.**, 1450 Koll Circle, Suite 105, San Jose, CA 95112. Phone (408) 298-4844. **Circle No 180**

DIGITAL PATTERN GEN. Model 710A's hex keypad and display permit easy data entry. The unit generates patterns from 8 to 64 bits wide and 1024 bits deep, at a 10-MHz rate. It features programmability through keyboard or IEEE-488 controller, nonvolatile storage of digital patterns and expansion to 64-channel \times 1024-bit capability. \$2400. Delivery, 60 days ARO. **Moxon Inc.**, 2222 Michelson Dr, Irvine, CA 92715. Phone (714) 833-2000. **Circle No 181**

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service cards are valid for six months, so this issue keeps working for you.

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- **Must** be accompanied by a black-and-white photo and full pricing and availability information.
- **Must** be fully spec'd. Please tell us *why* the product is noteworthy. Brag about it. Give us enough information on which to adequately judge its merits.

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2.

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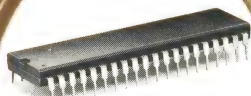
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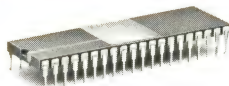
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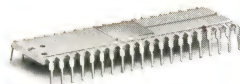
Floppy Disc
Hard-Sector Floppy Disc
Data Handler
FDC3400



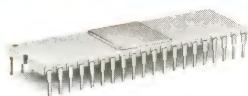
Cassette
Cassette/Cartridge
Data Handler
CCC3500



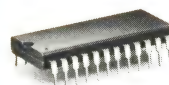
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CG4103
Static Shift Register
SR5015
Shift-Right/Shift-Left
Shift Register SR5017/18



Keyboard
Keyboard Encoders
KR2376
KR3600



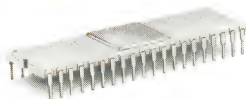
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COM8046/8116/8126/
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Character Generator CG7004
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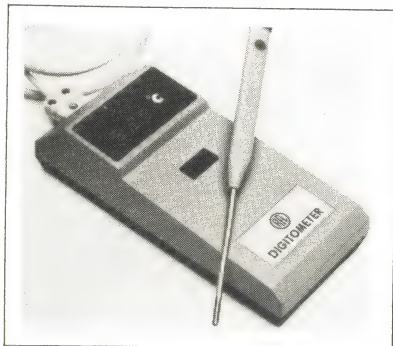


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COM8017/8502
USRT COM2601
Multi-Protocol USRT
COM5025
ASTRO COM1671

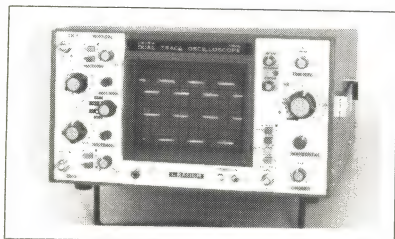
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We keep ahead of our competition so you can keep ahead of yours.

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New Products



DIGITAL THERMOMETERS. Unlike many competitive units, LED-readout Digitimeters come complete with probe and batteries. The standard Type-K liquid-immersible thermocouple probe covers -25 to $+250^{\circ}\text{C}$ (Model BDK-450) or -25 to $+482^{\circ}\text{F}$ (Model BDK-1000), with accuracy of $\pm 0.2\%$ of reading ± 1 digit; optional probes extend these ranges. An internal element provides cold-junction compensation. Four 1.5V AA alkaline cells give 10 hrs of continuous operation or 10,000 readings. \$340 for either model. **RFL Industries Inc.**, Boonton, NJ 07005. Phone (201) 334-3100. **Circle No 182**

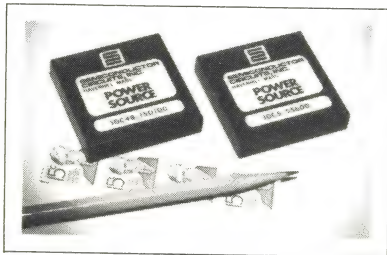


10-MHz SCOPES. Both the single-trace Model LBO-53 and the dual-trace Model LBO-514 furnish 8×10 -cm display, Z-axis modulation, $\times 5$ magnifier and complete trigger controls. Sensitivity reaches 1 mV on both units. Extensive use of ICs reduces instrument parts count and permits design simplification. Model LBO-514 also features X-Y operation, CH-1/CH-2 trigger selection and alternate or chopped display modes. \$499 for LBO-53; \$649 for LBO-514. **Leader Instruments Corp.**, 151 Dupont St, Plainview, NY 11803. Phone (516) 822-9300. **Circle No 183**

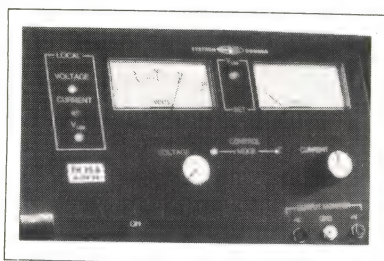
TINY SWITCHERS. Able to hide under a penny, units in the $0.5 \times 0.5 \times 0.5$ -in. $\mu\text{S-A}$ Series of switching-mode power supplies deliver up to 30 mW of output. Available models output 1.5 to

15V, regulated or unregulated, and operate from 47- to 440-Hz input. Full-output models accept either 120 or 240V input, while a reduced-output version operates from 90 to 255V without switching. I/O isolation specs at 2500V. \$2.86 (100). **Microsource Corp.**, 7330 Rogers Ave, Chicago, IL 60626. Phone (312) 465-8420.

Circle No 184

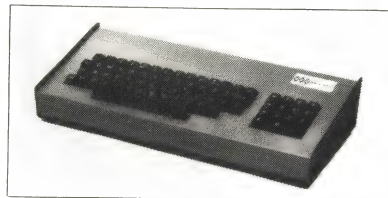


DC-DC CONVERTERS. Series 30 units' low output noise (5 mV p-p max for dual-output models, 8 mV p-p max for single-output models) fits them for demanding applications. Common specs for the 12 devices in the line show full output to 71°C ambient, $< 1\%$ reflected input ripple, 55 to 75% efficiency, a $2 \times 2 \times 0.4$ -in. case and 300V I/O isolation. Available input can be 4.5 to 5.5, 10.8 to 15, 21.6 to 30 or 42 to 56V dc; output, 5V/600 mA, $\pm 12\text{V}/125$ mA or $\pm 15\text{V}/100$ mA. \$74.75. **Semiconductor Circuits Inc.**, 218 River St, Haverhill, MA 01830. Phone (617) 373-9104. **Circle No 185**



PROGRAMMABLE SUPPLIES. Four quarter-rack models (10V/3A, 20V/2A, 50V/1A, 100V/0.5A) and four half-rack 150W models (10V/10A, 20V/6A, 50V/3A and 100V/1.5A) make up the series. Each unit can have its output voltage, current and voltage limit controlled by IEEE-488 bus, external analog signals or manually. Outputs respond to programmed changes in 1 to 2 msec; current-sink circuitry discharges load capacitance. \$495 to \$625. **Systron-Donner**, 10 Systron Dr, Concord, CA 94518. Phone (415) 676-5000. **Circle No 186**

COMPONENTS & PACKAGING



KEYBOARD. Designed specifically for personal, business and educational μC systems, Model 771 includes 56 alphanumeric keys which provide the full ASCII set (including lower case) and a separate 15-key numeric/cursor control keypad.

Four encoding modes, including an upper-case-only mode, combine convenient entry of data with high throughput. Standard features include auto-repeat, 2-key rollover and fully buffered outputs. The unit is equipped with a parallel interface and D-series connector for easy interconnection.

The options allow users to tailor the keyboard to their specific application. Four power-supply options suit almost any available voltage source. A versatile interface permits user selection of data, strobe and parity sense. An optional adapter converts the keyboard to a self-contained transmitter with 110 to 9600 baud RS-232 or current-loop serial-data output. From \$150. **George Risk Industries Inc.**, GRI Plaza, Kimball, NB 69145. Phone (308) 235-4645. **Circle No 187**



R NETWORKS. Designed for precision linear, digital and microwave circuits, this line of thin-film-on-ceramic chip resistors provides 20Ω to 500-k Ω resistance and 15- to 400-mW power ratings. The chips range in size from 0.02×0.04 to 0.1×0.1 in. and are laser-trimmed to standard tolerances of 1 and 5% (0.05% on special order). Long-term stability is typically 0.1%/1000 hrs at 125°C . The standard terminations are gold, nickel-gold or nickel-solder. **Electro Films Inc.**, 100 Meadow St, Warwick, RI 02886. Phone (401) 738-9150. **Circle No 188**



Gain huge savings—in dollars and inches—by replacing bulky conventional oscillators with tiny IC circuits.

WHILE CONVENTIONAL OSCILLATORS (FUNCTION GENERATORS, WAVEFORM GENERATORS, VCO'S, ETC.) COST UP TO SEVERAL HUNDRED DOLLARS, A SINGLE-CHIP IC OSCILLATOR CAN LITERALLY DO THE SAME JOB...AND FOR AS LITTLE AS \$1.72. All you give up for this tremendous reduction in cost and size is a certain degree of regulation in the output, and a variety of knobs and controls. But let's be realistic—for most applications, the IC oscillator is perfectly adequate. Its small size and low price makes the alternate approach quite impractical.

Nothing left out in the process.

Despite its small size, an IC chip really does contain every operating section of a traditional function generator. Consider a typical semiconductor oscillator, the XR-2206. On-chip you find the oscillator circuit (to generate the basic periodic waveform); the wave shaper to give you a clean sinewave; the modulator section (for AM capability); and an output drive amplifier. Basically the selfsame circuitry you'd receive if you bought a standard oscillator or benchtop function generator hundreds, even thousands of times as big as the IC.

But the real payoff comes in the outputs of these oscillators, and here too you lose nothing by going solid-state. The IC

oscillator will generate a combination of eight different types of output waveforms: triangle, ramp, sawtooth, squarewave, sinewave, pulse and FSK (frequency-shift keying) outputs, each with its own appropriate range of applications.

Just the item for sweep generators and sweep modulators.

The sweep generator, with its output hodgepodge of frequencies, can be a complex device. Yet it's a circuit easily built with ICs. A triangle-, ramp- or sawtooth-wave generator (XR-2207) modulates another oscillator (XR-2206) set up for voltage-to-frequency conversions. And presto! You have a functioning pocket-size sweeper.

Digital test equipment and stable phase-locked loop design.

Where space is at a premium, the solid-state precision voltage-controlled oscillator (XR-2209) comes to the rescue with banners flying. It more than meets the functional accuracies required, saves pounds and inches, and shaves dollars too.

Audio test equipment too.

Low cost is the prime requisite here, and once again the IC oscillator comes through for the design engineer. Solid-state sinewave generators (XR-2206 or XR-8038) are ideal, low-cost, simple solutions that often can offer a size and power advantage perfect for the test or hobby market.

Digital communications, including data-interface or acoustical-coupled MODEMS.

The FSK oscillator is tailor made to solve this design dilemma. Modern designers, particularly those dealing with computer and data-processing systems, are continually put upon to squeeze more capability into ever decreasing amounts of space. Where board space is tight, the IC FSK oscillator (XR-2206 or XR-2207) is magnificently effective in compressing a complex function into a nutshell. You wind

up with inches of real estate for really important things such as more memory.

Digital testers, logic circuits, on/off gating.

Naturally, there's an IC oscillator for the purpose. This time one with a pulse output (XR-

2206 or XR-2207). All the same advantages you find in other applications—size, cost, low power requirements—apply here as well. In short, regardless of where you need to use an oscillator or function generator, there's an outstanding chance you can find a solid-state device to do the job and make you a hero in the bargain.

Beware. Only one company produces a complete line of IC oscillators.

With a stable of five different circuits, Exar boasts by far the industry's broadest choice of IC oscillators. From low cost, easy-to-use devices to high performance function generators, the line is summarized in Table 1. Check them out, find the one best suited for your use, then make the shrewd move to solid state.

Exar's Function Generator Data Book contains technical articles and application notes. To request your copy, write on your company letterhead to your nearest Exar representative or to Exar, 750 Palomar Avenue, Sunnyvale, California 94086.

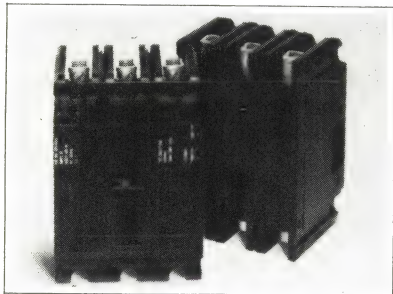


Electrical Characteristics	EXAR Device Type				
	205	8038	2206	2207	2209
Output Waveforms	Triangle, Square, Sine			Triangle, Square	
Upper freq. limit (MHz)	4	1	1	1	1
Sweep range	7:1	1000:1	2000:1	2000:1	2000:1
Typ. temp. Drift (PPM/°C)	300	50	20	20	20
Typ. sinewave distortion	2.5	0.5	0.5	—	—

Table 1. Exar's line of IC Oscillators.

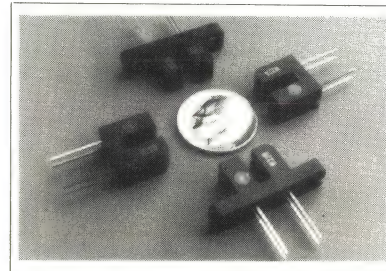
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New Products



CIRCUIT BREAKERS. Accommodating 250V at each pole, GH Series units feature three time-delay choices, ratings of 15 to 100A and a 10,000A interrupt capacity. These fully magnetic breakers carry 100% of rated load without derating; changes in temperature have no effect on current rating, must-trip point (125% rated load) or instantaneous-trip point. An inverse time delay protects against nuisance

trips caused by normal starting surges. **Heinemann Electric Co.**, Magnetic Dr., Trenton, NJ 08650. Phone (609) 882-4800. **Circle No 189**



INTERRUPTER MODULES. H21/H22 Series devices are compatible with logic systems from CMOS to relays. The units provide a consistent light beam with maximum dimensions of 1×1.5 mm, up to 25-mA minimum output and 55V blocking capability. The line includes 24 types: 12 transistor detectors feature low saturation voltage (<0.4V at 1.8 mA), and 12 darlingtontons feature high output current (≥50 mA at 1.5V). **General Electric Co.**, W Genesee St., Auburn, NY 13021. Phone (315) 253-7321.

Circle No 190

MIXERS. Model MHP-106 operates over a 1- to 2500-MHz range with an IF of 1 to 2000 MHz. This medium-power-level device (17-dBm LO power) has a 1-dB compression point of 10 dBm min from 1 to 1000 MHz and 8 dBm min from 1000 to 2500 MHz. Full MIL-STD-202E performance is guaranteed. Contained in a hermetically-sealed 8-pin plug-in or solder-pin package, the MHP-106 measures 0.4×0.4×0.8 in. \$50. **Engelmann Microwave Co.**, Skyline Dr., Montville, NJ 07045. Phone (201) 334-5700.

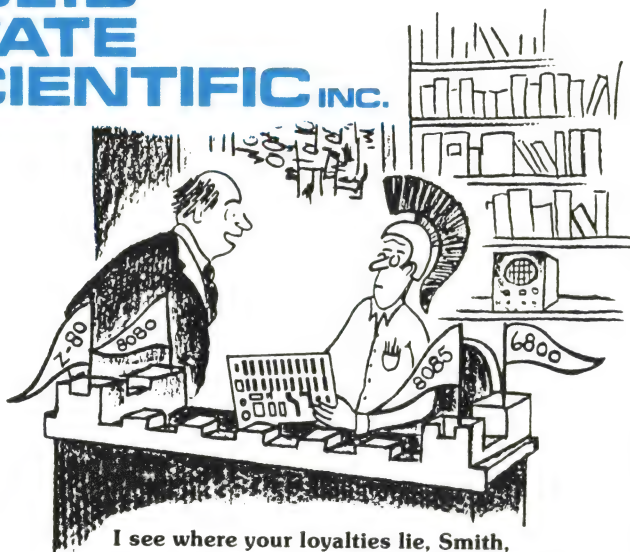
Circle No 191

MIXER. Model MD-159 is a 5- to 1000-MHz double-balanced mixer that provides a typical VSWR of 1.1:1. Other typical specs include 45-dB LO-to-RF isolation, 6-dB midband conversion loss and SSB NF within 1 dB of conversion loss. Typical two-tone IM ratio (with a -10-dBm input for each tone at 10-MHz separation) is 50 dB at 500 MHz. All specs apply with 50Ω source and local impedance and 7-dBm available LO power. \$55. **Anzac Electronics**, 39 Green St., Waltham, MA 02154. Phone (617) 899-1900.

Circle No 192



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I see where your loyalties lie, Smith,
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SCIENTIFIC'S 1802 MICROPROCESSOR.

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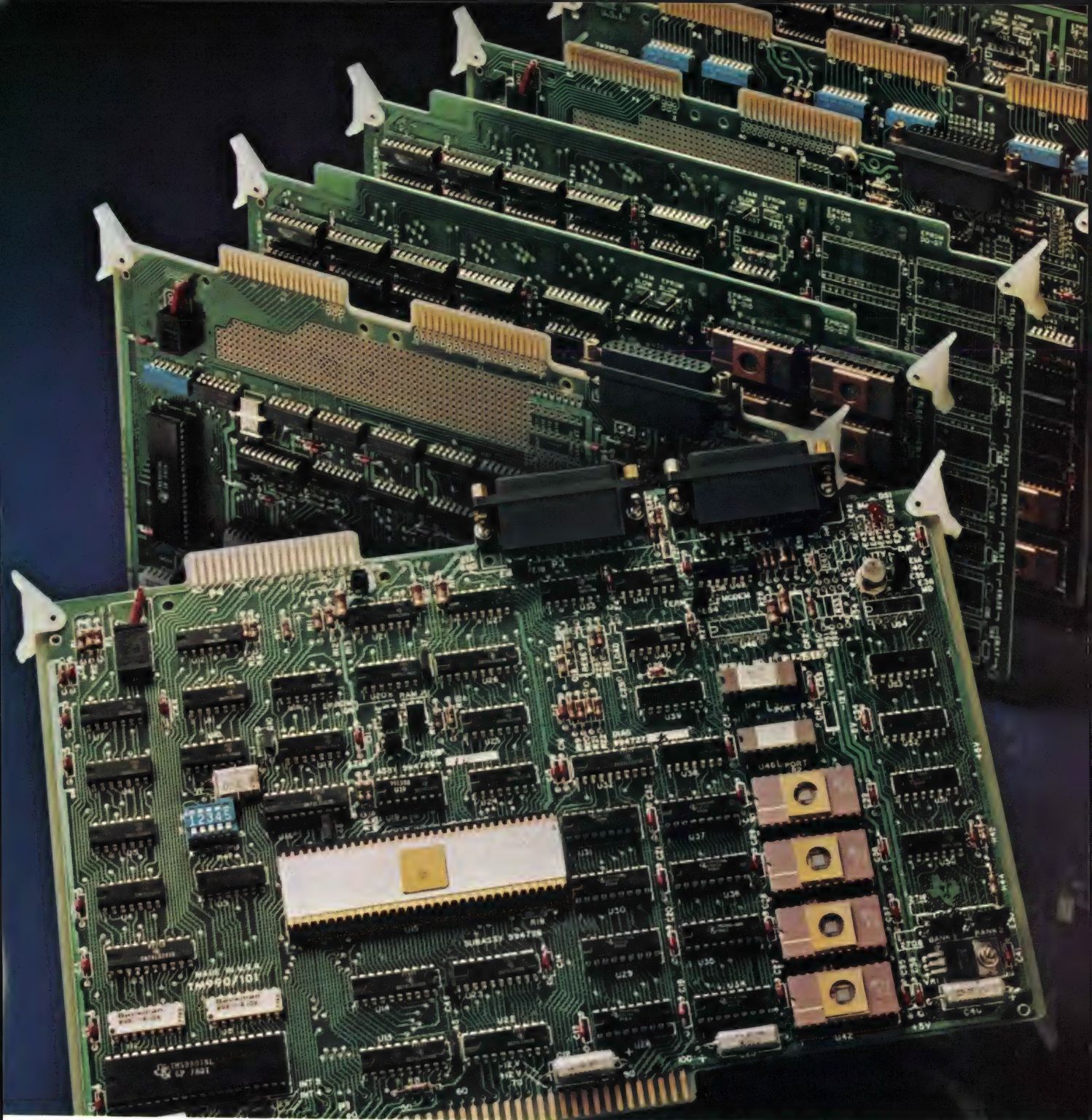
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A Trans Union Company
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For more information, Circle No 85



Joining the growing 990/9900 Family:

First 16-bit microcomputer with BASIC. Easier to program. More capability to store. Remember. Communicate.

Now available from your local TI distributor, true single-board computers. TI's new TM 990/101M microcomputer modules. More memory than ever before. Simultaneous dual communication. With

communication protocol on the board and POWER BASIC* high-level language on the TM 990/101M-10 to make programming faster, easier.

These new modules from TI save

you design and development time. Cut the number of system components. Reduce costs and improve reliability.

They're preassembled. Pre-tested. Ready to plug in.

Four times the memory

The TM 990/101M microcomputers come with as much as four times the static RAM on board: up to 2K by 16 bits. The EPROM is either 2K by 16 bits or 4K by 16 bits.

Double the communication capability

Also on board: two serial communication ports. One for "remote" usage such as a terminal or modem. The other for "local" usage with an EIA terminal, a teletype, or TI's TM 990/301 microterminal.

The most in microcomputers

In TI's TM 990 Series, you have the widest available choice of cost-effective, 16-bit microcomputers to meet your system needs. Ideal for microprocessor evaluation. To speed your microprocessor-based design to market. Or as a production alternative. And all are instruction-set compatible with other members of TI's 990/9900 First Family.

For evaluation and OEM applications:

- TM 990/100M — Utilizes TI's NMOS 16-bit TMS 9900 microprocessor. Includes 1024 bytes of static RAM, 2K bytes of EPROM, and programmable serial and parallel I/O to form a powerful, single-board microcomputer.
- TM 990/180M — Provides 2.5 MHz operation. Incorporates an 8-bit memory interface.
- TM 990/189M — A self-contained, assembled, single-board 16-Bit Microcomputer System complete with integral keyboard, system monitor, symbolic assembler, 500 page Tutorial Text and 200 page User's Guide.

For memory expansion:

- TM 990/201 — 8K bytes of EPROM and 4K bytes of static RAM. Expandable to 32K bytes of EPROM and 16K bytes of RAM.
- TM 990/203 — Dynamic memory module with up to 64K bytes capacity with parity.
- TM 990/206 — 8K bytes of RAM expandable to 16K bytes.

For data entry and display:

- TM 990/301 — Provides hexadecimal entry of program data, as

well as display and modification of internal registers and memory under software (TIBUG*) control.

For I/O expansion:

- TM 990/310 — A 48-bit input/output expansion module.
- TM 990/305 — Up to 32K bytes memory capacity using pin compatible static RAMS and/or EPROMS. Plus 32 optically isolated I/O lines, 16 dedicated parallel input lines and 16 user-configurable parallel I/O lines.

For A/D, D/A and digital I/O industrial interfaces:

- 16 new TM 990 Bus Compatible Modules — 7 A/D and D/A modules — 9 AC and DC input and output modules.

For development and production:

- TM 990/302 Software Development Module — Includes ROM resident symbolic assembler, text editor, loader, debug package. EPROM programming, dual audio cassette interface, and POWER BASIC development options.
- TM 990/401 — Interactive debug monitor (TIBUG) preprogrammed into EPROM.
- TM 990/402 — Line-by-line assembler preprogrammed into the EPROM.
- TM 990/450 — 8K POWER BASIC preprogrammed into ROM.
- TM 990/451 — 12K POWER BASIC preprogrammed into ROM.
- TM 990/452 — POWER BASIC option — EPROM programming and audio cassette interface.
- Configurable Basic — TMS W510F floppy based Industrial Basic allowing minimum memory configuration.

OEM card cages, cables, connectors, extender and prototyping boards are available.

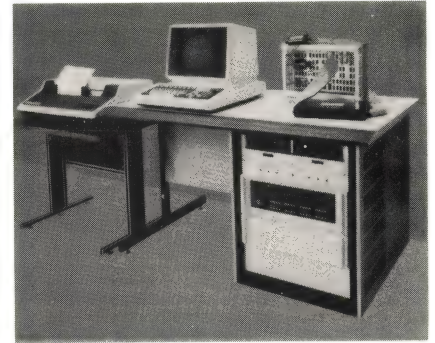
Time-saving software support

The TM 990 microcomputers are fully supported by TI's Advanced Microprocessor Prototyping Laboratory. AMPL* features 10 MHz trace capability and universal emulation for the TMS 9900, SBP 9900, TMS 9980, and TMS 9940 microprocessors as well as others to come.

*Trademark Texas Instruments Incorporated

AMPL is available as a floppy diskette system or as a disk system that accommodates multiple users. Programs can be edited, assembled, linked, loaded, and executed much faster than conventional paper tape or cassette based systems.

The 9900/9980 emulation allows development and debugging of software directly on a TM 990 module while monitoring and controlling the operation from the AMPL prototyping system.



For today and tomorrow: the 16-bit First Family

The TM 990 Series microcomputers and AMPL are integral members of TI's pace-setting 990/9900 First Family. A mature, proven family already providing the power and performance of 16 bits that many others are just beginning to imitate.

It's a broad, readily available selection of compatible microprocessors, microcomputers and minicomputers using the same advanced memory-to-memory architecture. Same instruction set. Same development system. All software supported and software compatible.

The 990/9900 Family gives you flexibility and economy to meet today's specific needs. And provides the base to improve and innovate as your needs change while protecting both your hardware and software investments.

For technical assistance on the TM 990 Series microcomputers, call your TI Field Sales Office. For more information, call your TI distributor or write: Texas Instruments, P.O. Box 1443, M/S 6404, Houston, Texas 77001.

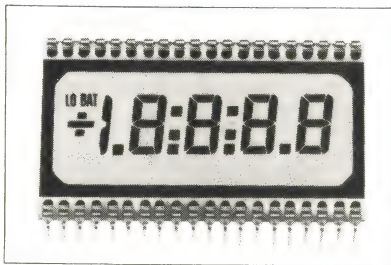
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MOVING AHEAD
IN MICROCOMPUTERS**



TEXAS INSTRUMENTS
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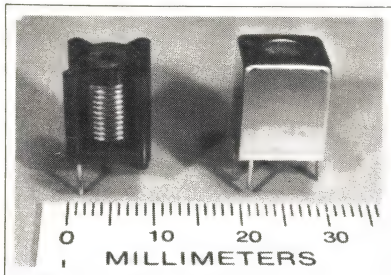
For more information, Circle No 86

New Products



DISPLAY. The 4-1/2-digit Model FE0206 liquid-crystal display features a 0.4-in. digit height, four decimal points, "low-battery" annunciator, +/— sign and two colons. The unit is available in transmissive, reflective and transreflective modes and can be purchased with DIP pins or in a leadless version for use with elastomeric connectors. Crystal materials are available in two operating ranges: -10 to +55°C and -5 to +90°C. Red, blue and green readouts are available on special order. \$11.25 (100). **AND**, 770 Airport Blvd, Burlingame, CA 94010. Phone (415) 347-9916.

Circle No 193



COILS. Tuneable Uni-10 devices employ a precision winding in a single molded piece of polypropylene plastic to assure mechanical and electrical stability. Nominal inductance for a 1-1/2-turn coil with a 0.25-in.-long carbonyl E core is 0.059 μ H; a 10-1/2-turn unit yields 0.429 μ H. Typical Q for the latter is 100 at 40 MHz. The coils' hex-hole core tunes more easily than slotted cores. \$0.10 (5000). **Coilcraft**, 1102 Silver Lake Rd, Cary, IL 60013. Phone (312) 639-2361.

Circle No 194

SWITCHES. Series TH lighted push-buttons convert from alternate to momentary action through movement of a lever accessible through a window in the switch body. Three available models include: TH01 with tapered bezel, TH31 with straight bezel and TH42 with covered bezel. Wipe-and-roll gold-plated-silver con-

tacts handle loads to 5A at 250V ac. Most units come with round, square or rectangular lenses (translucent or transparent) and up to 4-pole switching capability. \$3.55 (1000) for TH01.

Unimax Switch Corp, Ives Rd, Wallingford, CT 06492. Phone (203) 269-8701.

Circle No 195

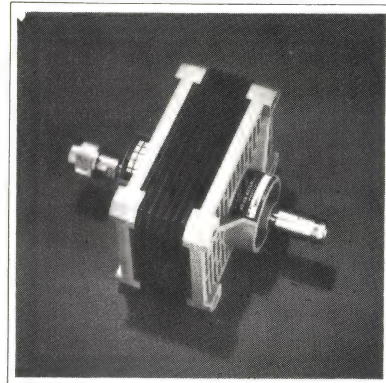
POSITION SENSORS. This line of contactless linear and rotary sensors serves industrial applications; the linear units have two ferrite-tube inductors connected in series and mounted between a movable plunger assembly containing two ceramic permanent magnets. When a unit is driven with an ac signal, its output is an ac voltage with amplitude proportional to the plunger position. Output of the similarly constructed rotary units varies linearly with shaft angle. Approx \$20. **Licon Div/ITW Inc**, 6615 W Irving Park Rd, Chicago, IL 60634. Phone (312) 282-4040. **Circle No 196**

ASSEMBLY PANELS. Mountable on 0.5-in. centers, W9302 hex wire-wrapping modules accommodate up to 96 DIP ICs or sockets; 55 positions are dedicated to 16-pin devices and 11 to 20-pin units. These dedicated positions are prewired for ground and power. In addition, power and ground pads accommodate ceramic decoupling capacitors at 55 locations. Two I/O positions serve ribbon-cable edge connectors with up to 50 conductors, and 2-level wrapping posts are installed on the boards' component side. **MDB Systems Inc**, 1995 N Batavia St, Orange, CA 92665. Phone (714) 998-6900. **Circle No 197**

SOCKET BOARDS. The metric DMPS series of packaging panels offers a 160×233-mm board with an I/O area compatible with European right-angle wire-wrappable, 96-pin connectors. The Schottky-TTL construction combines two outside ground planes with a sandwiched V_{CC} plane. Socket/terminals have brass sleeves with gold-plate over nickel or a 200- μ in. electro-tin finish. The four-tine spring-socket members are gold-plated beryllium copper and are available with three lengths of wire-wrapping or rectangular-post terminations. \$150 to \$350. Delivery, 4 to 6 wks ARO. **Garry Mfg Co**, 1010 Jersey Ave, New Brunswick, NJ 08902. Phone (201) 545-2424. **Circle No 198**

HEAT SINKS. Series 6075 components feature a universal hole pattern for 2-, 3- and 4-lead TO-3, TO-127 and TO-220 plastic power devices. For a 75° rise, thermal resistance specs at 6.25 (6077B), 7.4 (6076PB) and 11 (6075PB) °C/W. The sinks' U-shaped stampings require little board space; the components are a good choice in applications where vertical space is plentiful. The heat sinks come in pre-black-anodized aluminum material. \$0.08 to \$0.15 (1000). **Thermalloy Inc**, Box 34829, Dallas, TX 75234. Phone (214) 243-4321. **Circle No 199**

SWITCHES. 39000 Series thumbwheels are only 0.315 in. wide and include an isolated switching chamber for extra protection against dust and debris. Units are available with 10, 11, 12 or 16 positions (with field-installable dial stops) in a wide variety of output codes. The front-mounted modules feature 0.2-in.-high characters, a gold contact system and G-10 circuit board. The units assemble without tools and come with solder or optional pin terminations. \$3.15/module (100). **Digitran Co**, 855 S Arroyo Parkway, Pasadena, CA 91105. Phone (213) 449-3110. **Circle No 201**



ATTENUATOR. Intended for broadband coaxial measurements at medium power, the 8498A offers 30-dB attenuation and covers a dc to 18-GHz range. It has a standing wave ratio of 1.3 at 18 GHz, and its attenuator pad is bilateral so that either end accepts 25W inputs. No adapters are needed because the standard connector configuration uses one Type-N male and one Type-N female. \$475. Delivery, 8 wks ARO. **Hewlett-Packard Co**, 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 493-1501.

Circle No 202

Ampex non-volatile RAM for 8080. 16K bytes \$885.

Now Ampex gives you proven, non-volatile RAM in a single-board, 16K byte module: the MCM-8080. It'll work with Intel SBC 80/05, 80/10 and 80/20, System 80, the MDS-800 Microcomputer Development System, and the 888 System Development Center.

MCM-8080 is pin compatible with the Multibus*, fits in a single card slot, has data save for out-of-tolerance power supplies,

and won't lose data when the power goes off.

Remember, a system is only as reliable as the memory, and Ampex non-volatile core RAM is the most reliable memory you can use. Write Ampex Memory Products Division, 200 North Nash Street, El Segundo, California 90245. Or call Ted Conant at 213/640-0150. Try 16K bytes of reliable memory for only \$885.

AMPEX

*Trademark, Intel Corporation

For more information, Circle No 87

We Protect Your Reputation

The hefty power supply module will power two duplicators simultaneously. Load one unit while the other is duplicating.

Tests and Duplicates 1 to 16 EPROMS simultaneously.

Reliable single board construction and LSI components.

Solid state audio transducer informs the operator of incorrectly inserted devices or test failures.

AUTO PROG-single key automated test-program-verify sequence.

40 pin Personality Module contains the programming algorithm and reference voltages for a complete generic EPROM family.

Fast 8048 processor performs comprehensive diagnostics in seconds, not minutes!

Put an end to costly and embarrassing field failures caused by marginal EPROMS with the first Production Duplicator that "tests" your EPROMS both *before* and *after* programming!

Whether you are programming 1 or 100 EPROMS a day, you can't afford a marginal EPROM in your end product. OAE's new Programmer includes an exclusive set of "test" routines designed to detect poorly erased or static damaged EPROMS which would otherwise pass a Verify test.

And it's so easy to use — simply touch the AUTO PROG key and the UPP-2700 will automatically test and program 1 to 16 EPROMS. Or, use the other 15 keys to access the individual test routines.

A small 40 pin Personality Module contains the test and programming algorithms for a specific generic EPROM family. This open-ended design does not limit the UPP-2700 to current or "projected" EPROMS. Personality Modules are currently available to handle all of the following EPROMS:

PM-1: 2704, 2708, 27L08; **PM-2:** TMS-2716; **PM-3:** 12758, 12716, TMS-2516; **PM-4:** TMS-2532.

The UPP-2700 could pay for itself in its first week of operation. Can you afford to be without it?

Protect your profits . . . Call us today!

UPP-2700 PROGRAMMING SYSTEM includes power supply and one Personality Module (please specify) . . . \$2450.00

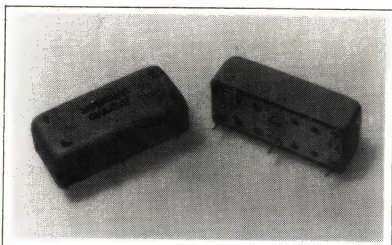
Second UPP-2700 Programmer (please specify Personality Module) . . . \$1995.00

For more information, Circle No 89



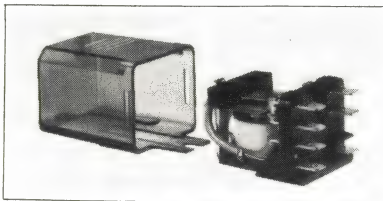
Oliver Advanced Engineering Division
676 West Wilson Avenue
Glendale • Ca. • 91203
(213) 240-0080

DPM. Model 3362 features a full-scale capability of ± 5999 counts with a bright 0.55-in. gas-discharge display. External control signals include hold, trigger, blank, read-rate and decimal point. Output signals include polarity and overrange; read-rates to 8 samples/sec are available. Options include parallel BCD output and offset for process applications. The unit is housed in a standard NEMA-size case. \$118 (OEM qty). **Data Tech**, 2700 S Fairview, Santa Ana, CA 92704. Phone (714) 546-7160. **Circle No 206**



HYBRIDS. Series QHS-6 quadrature 90° hybrids are aimed at amplifier-combining, SSB-generator, image-reject mixer and radio direction-

finding applications. Three units make up the line: QHS-6-17, 2 to 32 MHz; QHS-6-42, 3.5 to 80 MHz; and QHS-6-225, 50 to 400 MHz. All units have a 3-dB coupling loss, 20-dB isolation (15 dB for the -225), 1-dB amplitude balance and 1.5-dB insertion loss. VSWRs are 1.3, 1.35 and 1.5, respectively. The units are housed in a miniature pc-board plug-in package. \$195 to \$245. **Merrimac Industries Inc.**, 41 Fairfield Pl, West Caldwell, NJ 07006. Phone (201) 575-1300. **Circle No 207**



RELAYS. Type 188 relays are rated for 30A at 28V dc, 120/240V ac (80% power factor) and 1 hp at 120V ac. They are available in Form X, Y and Z contact arrangements. Standard input-coil voltages range from 6 to

100V dc and 6 to 220V ac. The relays provide 0.25-in. combination quick-connect/solder terminals and are offered with either a standard or open-style, stud-mounted, plastic-flanged dust cover. \$3.56 (2500) for Form Z, 120V-ac-coil unit. Delivery, stock to 6 wks ARO. **MidTex Inc.**, 1650 Tower Blvd, North Mankato, MN 56001. Phone (507) 625-6521.

Circle No 208

I/O SWITCHES. S442 and S443 solid-state ac-output switches provide an electrically clean, photoisolated, noise-free interface between sensitive controls and their load-field elements. Both units have a load-current rating of 2A at 40°C and 1.3A at 70°C. The S442 features a 30 to 140V-ac rms range, while the S443 is rated at 60 to 280V-ac rms. The devices are fully potted and have an internal heat spreader for optimum thermal management. S442, \$12.25 (50); S443, \$12.85. Delivery, stock to 6 wks. **International Rectifier Corp.**, 1521 E Grand Ave, El Segundo, CA 90245. Phone (213) 322-3331. **Circle No 209**

The NEW GENERATION of PHI-DECK® Cassette Transports

- Cast Chassis
- Four Motors
- Fully Remote Controllable

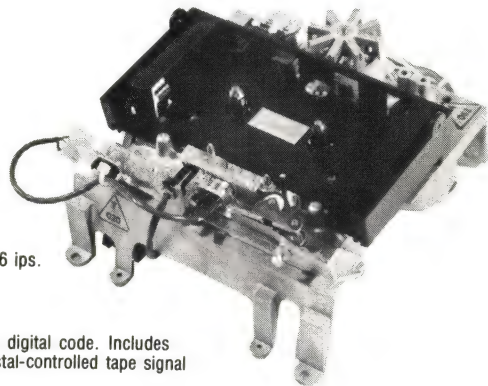
FIXED SPEED DECK with AC CAPSTAN MOTOR - Single speed transport. Excellent speed regulation from synchronous AC capstan motor. $1\frac{3}{16}$, $1\frac{1}{8}$, $3\frac{3}{4}$, 5, 6, 7, 8, or 10 ips.

FIXED SPEED DECK with DC CAPSTAN MOTOR - Lowest cost, single speed transport. $1\frac{1}{8}$, 2, $3\frac{3}{4}$, 5, or 6 ips.

OPTO-TACH TRANSPORT - Precise speed control. Optical tachometer allows digital selection of 2 speeds.

SELECTO-SYNC SYSTEM - Our most advanced synchronous drive system. Any of 15 speeds selected by digital code. Includes transport, motion control, and speed selection circuitry. Optional ULTRA-SYNC board provides crystal-controlled tape signal synchronization for the ultimate in precision tape movement.

HI-PHI-DECK - Designed for high quality audio applications. Precision components provide typical 0.05% wrms Wow and Flutter.



and ELECTRONICS developed exclusively for PHI-DECK

MOTION CONTROL BOARDS for DC, AC, OPTO-TACH - Accepts 5 volt CMOS signals to initiate Run, Stop, Fast Forward, and Fast Rewind. Tape tension, braking, and motion sensing are automatically controlled.

UNIVERSAL MOTION CONTROL BOARDS - Provides complete deck control for all models of PHI-DECK. Provisions for plug-in boards for bi-directional operation and solenoid controlled pinch roller operation.

COMBINED MOTION CONTROL and RECORD/PLAY AMPLIFIER - Stereo R/P operates from a single 12 volt supply. Line and microphone inputs, line and speaker outputs. Record/Play electronics available separately.

COMBINED MOTION CONTROL and READ/WRITE AMPLIFIER - For saturated digital recording and reading. TTL level data interface logic. Recording density up to 1600 FRPI. Read/Write electronics available separately.

ADDRESSABLE SEARCH SYSTEM BOARD - Zeros in on precise address with average access speed of 120 ips. Location is accurate within one audio word. Provisions for either keypad or computer entry of desired tape position.

- The exciting new **TEAC MT-2** series of Digital Cassette Transports is distributed in the U.S. exclusively by Triple I, Inc. Contact us for complete details.



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A Designer's Guide to FIBER OPTICS

This comprehensive, authoritative guide covers all aspects of fiber-optic systems. Totalling 60 pages, it provides full understanding of the components, their key parameters and how they relate to fiber-optic system design.

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- **Part 2** — Matching sources and detectors to the fibers
- **Part 3** — System-design considerations
- **Part 4** — Building a fiber-optic system
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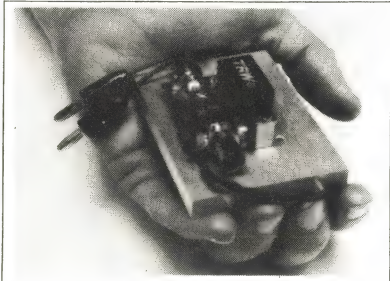
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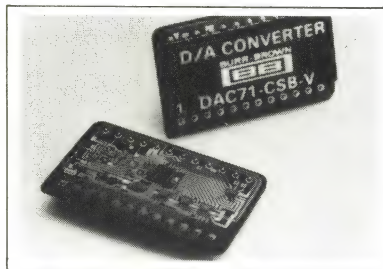
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New Products



TEST PACKAGE. The Demonstrator consists of an evaluation fixture and one high-power hybrid amplifier. Two amplifiers—both having a 30-dB gain and operating over a 1- to 520-MHz range with ± 1 -dB flatness—are offered: CA2820 which operates on 16 to 28V and delivers 0.5W, and CA2812 which operates on 8 to 15V and outputs 0.3W. The test fixture includes a base plate for the heat sink, pc board with BNC connectors, banana jacks for connecting a power supply and gold-plated pin sockets for terminating the amplifier. **TRW Semiconductors**, 14520 Aviation Blvd, Lawndale, CA 90260. Phone (213) 679-4561. **Circle No 210**

ICs & SEMI-CONDUCTORS



16-BIT DAC. Offering 16-bit, 4-digit resolution and $\pm 0.003\%$ linearity error, Model DAC71 settles in 10 μ sec to $\pm 0.003\%$ FS. Six models give a choice of complementary straight-binary, complementary offset-binary and complementary decimal input codes, as well as voltage (0 to 10V or ± 10 V) or current (0 to -2 -mA or ± 1 -mA) outputs. Gain drift is limited to ± 15 ppm/ $^{\circ}$ C over 0 to 70 $^{\circ}$ C. The 24-pin ceramic hybrid DIP requires ± 15 and ± 5 V supplies. \$39 (100). **Burr-Brown**, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. **Circle No 223**

DC-MOTOR SPEED CONTROL. Essentially a phased-locked-loop IC, the CS-175 is intended primarily for use with ac tachometer signals from dc motors. With this circuit in operation, the external compensation required to ensure motor stability dominates motor-speed errors. For multiple-speed requirements, pin-programmed speed ratios of 1.333:1, 1.5:1 and 2:1 are included. The 14-pin DIP contains a tachometer input comparator, a voltage-controlled one-shot, a phase comparator, a current-limited output amp and a reference voltage. Nominal supply voltage equals 6V dc. \$0.79 (1000). **Cherry Semiconductor Corp.**, 99 Bald Hill Rd, Cranston, RI 02920. Phone (401) 463-6000. **Circle No 224**

4-1/2-DIGIT COUNTER/DRIVERS. Featuring guaranteed counting up to 15 MHz (25 MHz typ), ICM7224 and 7225 use CMOS technology to achieve low-power operation (1 μ A at 10 kHz, 2 mA at 20 MHz). The devices operate as decade counters to 19999 or as timers



WIRE FOR WIRE-WRAPPING



CUT TO LENGTH AND PRE-STRIPPED ON BOTH ENDS

AWG 30 (0.25MM) KYNAR WIRE					AWG 28 (0.32MM) KYNAR WIRE					AWG 26 (0.40MM) KYNAR WIRE				
INSULATION DIAMETER: 0.195 INCH (0.50MM) STRIP-OFF LENGTH BOTH ENDS 1 INCH (25MM) 500 WIRES PER PACKAGE					INSULATION DIAMETER: 0.23 INCH (0.59MM) STRIP-OFF LENGTH BOTH ENDS 1 INCH (25MM) 500 WIRES PER PACKAGE					INSULATION DIAMETER: 0.27 INCH (0.69MM) STRIP-OFF LENGTH BOTH ENDS 1 INCH (25MM) 500 WIRES PER PACKAGE				
LENGTH "L" INCH	BLUE PART NO.	WHITE PART NO.	YELLOW PART NO.	PRICE PER 500	BLUE PART NO.	WHITE PART NO.	YELLOW PART NO.	PRICE PER 500		BLUE PART NO.	WHITE PART NO.	YELLOW PART NO.	PRICE PER 500	
1	30B-010	30W-010	30Y-010	\$4.88	28B-010	28W-010	28Y-010	\$5.25		26B-010	26W-010	26Y-010	\$5.75	
1.5	30B-015	30W-015	30Y-015	5.19	28B-015	28W-015	28Y-015	5.63		26B-015	26W-015	26Y-015	6.23	
2	30B-020	30W-020	30Y-020	5.50	28B-020	28W-020	28Y-020	6.00		26B-020	26W-020	26Y-020	6.68	
2.5	30B-025	30W-025	30Y-025	5.82	28B-025	28W-025	28Y-025	6.38		26B-025	26W-025	26Y-025	7.13	
3	30B-030	30W-030	30Y-030	6.13	28B-030	28W-030	28Y-030	6.75		26B-030	26W-030	26Y-030	7.60	
3.5	30B-035	30W-035	30Y-035	6.44	28B-035	28W-035	28Y-035	7.13		26B-035	26W-035	26Y-035	8.05	
4	30B-040	30W-040	30Y-040	6.75	28B-040	28W-040	28Y-040	7.50		26B-040	26W-040	26Y-040	8.50	
4.5	30B-045	30W-045	30Y-045	7.07	28B-045	28W-045	28Y-045	7.87		26B-045	26W-045	26Y-045	8.98	
5	30B-050	30W-050	30Y-050	7.38	28B-050	28W-050	28Y-050	8.25		26B-050	26W-050	26Y-050	9.43	
6	30B-060	30W-060	30Y-060	8.00	28B-060	28W-060	28Y-060	9.00		26B-060	26W-060	26Y-060	10.35	
7	30B-070	30W-070	30Y-070	8.63	28B-070	28W-070	28Y-070	9.75		26B-070	26W-070	26Y-070	11.25	
8	30B-080	30W-080	30Y-080	9.25	28B-080	28W-080	28Y-080	10.50		26B-080	26W-080	26Y-080	12.18	
9	30B-090	30W-090	30Y-090	9.88	28B-090	28W-090	28Y-090	11.25		26B-090	26W-090	26Y-090	13.55	
10	30B-100	30W-100	30Y-100	10.50	28B-100	28W-100	28Y-100	12.00		26B-100	26W-100	26Y-100	14.00	

ROLLS OF WIRE

100 ft. roll	R30B-0100	R30W-0100	R30Y-0100	\$3.65	R28B-0100	R28W-0100	R28Y-0100	\$4.05	R26B-0100	R26W-0100	R26Y-0100	\$4.35
500 ft. roll	R30B-0500	R30W-0500	R30Y-0500	10.40	R28B-0500	R28W-0500	R28Y-0500	12.85	R26B-0500	R26W-0500	R26Y-0500	13.80
1000 ft. roll	R30B-1000	R30W-1000	R30Y-1000	16.82	R28B-1000	R28W-1000	R28Y-1000	21.10	R26B-1000	R26W-1000	R26Y-1000	23.15

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MINIMUM BILLING \$25.00.

ADD SHIPPING CHARGE \$1.00.

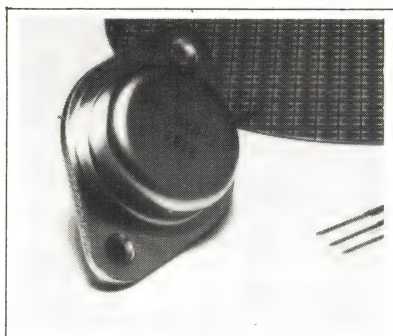
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New Products

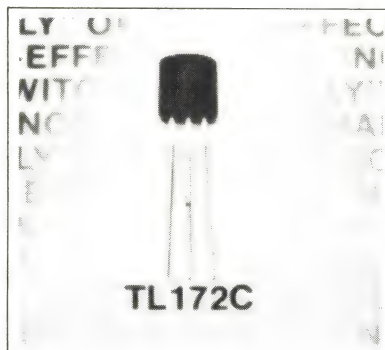
to 15959; Schmitt-trigger input assures accurate counting. The 7225 LED-driver has direct, nonmultiplexed, common-anode 8-mA segment drivers. The 7224 LCD version has an on-board backplane RC oscillator. Minimum operating voltages are 3V (7224) and 4V (7225). ICM7224, \$7 (100); ICM7225, \$5.30. **Intersil Inc.**, 10710 N Tantau Ave, Cupertino, CA 95014. Phone (408) 996-5000. **Circle No 225**



POWER MOSFETs. VN12 n-channel devices come with 40, 60, 80 and 90V ratings. Housed in a TO-3 package, the transistors supply 16A continuously or 32A pulsed. ON resistance of 0.25Ω and switching speed of <50 nsec make these devices interchangeable with IRF 100 units, and a gate threshold-voltage range of 0.8 to 2.5V simplifies TTL or MOS interfacing. A companion p-channel series, the VP12, offers the same voltage ratings. Units in this family supply 10A continuously or 30A pulsed; gate threshold voltage ranges from 1.0 to 3.0V. 80V VN12, \$12 (1000); 80V VP12, \$15. **Supertex Inc.**, 1225 Bordeaux Dr, Sunnyvale, CA 94086. Phone (408) 744-0100. **Circle No 226**

10-BIT DAC IC. Accepting TTL-compatible inputs, the DAC-IC10B features $\pm 1/2$ -LSB worst-case linearity error. An external reference current programs the device's scale factor and can be varied over a 4:1 range for multiplying operation. Output currents of 0 to 4 mA settle in 250 nsec to $1/2$ LSB. Output compliance is -2.5 V to $+0.2$ V, and gain TC is 20 ppm/ $^{\circ}$ C. The 16-pin ceramic DIP requires $+5$ V at 18 mA and -15 V at 20 mA. From \$14.50. Delivery, 4 wks. **Datel Systems Inc.**, 11 Cabot Rd, Mansfield, MA 02048. Phone (617) 828-8000, Ext 124. **Circle No 227**

LOW-EMI SWITCHING NPNs. Combining the economy of the TO-3 package with the versatility of an isolated-collector design, this family of transistors addresses problems encountered in high-voltage switching circuits. A reduction of collector-to-base capacitance reduces conducted interference by 20 to 30 dB; other benefits include reduced ground-loop currents, lowered assembly costs (no insulators required) and reduced shock hazards. V_{CE0} specs range from 200 to 450V; I_{CS} from 10 to 30A. \$7.10 to \$18.40 (100). **General Semiconductor Industries Inc.**, Box 3078, Tempe, AZ 85281. Phone (602) 968-3101. **Circle No 228**

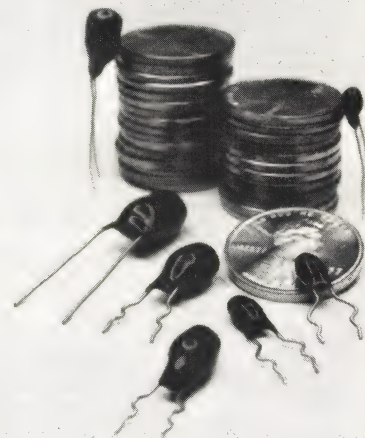


HALL-EFFECT SWITCH. Containing a Hall-effect sensor, signal-conditioning and hysteresis functions and an output transistor, the TL172C senses the presence of a magnetic field. A field of sufficient strength causes the output to switch from a high-impedance to a low-impedance state. \$0.43 (100). **Texas Instruments Inc.**, Box 225012, MS 308, Dallas, TX 75265. Phone (214) 238-5908. **Circle No 229**

LOW-COST ADC. For use with TMS-1000-type μ Cs, the TL507C contains a 7-bit synchronous counter, a binary-weighted resistor ladder, a summing amp, two comparators, a buffer amp, an internal regulator and logic circuitry. Using a single-slope conversion technique, the 7-bit-resolution, 8-pin DIP outputs a pulse whose duration is proportional to the analog input. Conversion speed equals about 1 msec. The unit operates on 8 to 18V from unregulated supplies or 3.5 to 6V from regulated supplies. \$0.65 (100). **Texas Instruments Inc.**, Box 225012, MS 308, Dallas, TX 75265. Phone (214) 238-5908. **Circle No 230**

SIEMENS

Economy DIP Tantalum Capacitors

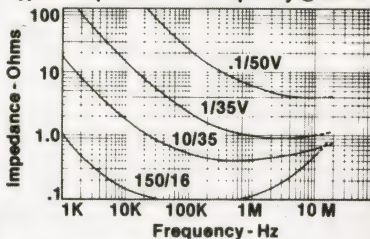


Siemens new ST841 and ST842 Sub-miniature Epoxy Coated Solid Tantalum Capacitors are the economical answer to Tantalum Capacitor applications.

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- Lead Styles of straight or "Lock-in" crimp
- Lead Spacings of 0.1 or 0.2 inch are available
- Manufactured in U.S.

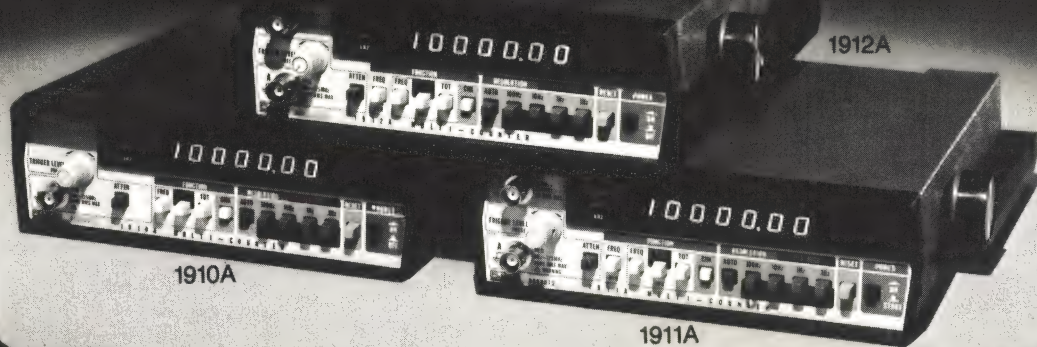
Typical Impedance vs. Frequency @ 25°C.



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New Time and Frequency.

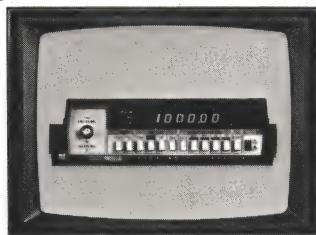
Last year's hit, the model 1900A, set the stage for this new series of multicounters by offering frequency, period, period average and totalize *standard* in one great counter.

Now all models in the series offer comparable features and value, with autoranging and autoreset as well.

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LAMBDA LAS 3905, 8 AMP, 80 WATT MONOLITHIC POSITIVE VOLTAGE REGULATORS

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	MINI-MUM	MAXI-MUM	UNITS
Input Voltage	V_{IN}	0	25 (1)	VOLTS
Input/Output Differential	$V_{IN}-V_{OUT}$	0	20 (1)	VOLTS
Power Dissipation @ $T_C \leq 94^\circ\text{C}$	P_D		80 (1) (2) (3)	WATTS
Thermal Resistance Junction To Case	θ_{JC}		0.7	$^\circ\text{C/WATT}$
Operating Junction Temperature Range	T_J	-55	150	$^\circ\text{C}$
Storage Temperature Range	T_{STG}	-65	150	$^\circ\text{C}$
Lead Temperature (Soldering, 60 Seconds Time Limit)	T_{LEAD}		300	$^\circ\text{C}$

Description

8 amp positive regulator

The LAS-3900 series voltage regulators are monolithic integrated circuits designed for use in applications requiring a well regulated positive output voltage. Outstanding features include full power usage up to 8.0 amperes of load variation, internal current limiting, thermal shutdown, and safe area protection on the chip, providing protection of the series pass Darlington, under most operating conditions. In addition, a sense terminal is provided for elimination of voltage drop problems at high currents. Hermetically sealed copper TO-3 packages are utilized for high reliability and low thermal resistance when used with an appropriate heat sink. A low-noise temperature-stable diode reference is the key design factor insuring excellent temperature regulation of the LAS-3900 series. This coupled to a very low output impedance insures superior performance and load regulation.

The LAS-3900 series of four terminal regulators is available in a fixed output voltage tolerance of $\pm 5\%$ with a nominal output voltage of +5 volts.

- (1) The maximum input voltage of the LAS-3900 Series is limited by the maximum input-output differential, maximum power dissipation, or the maximum current limit safe operating area, whichever is less.
- (2) For operation above 94°C T_{CASE} , derate @ $1.42 \text{ watt}/^\circ\text{C}$.
- (3) In case of a short circuit, the second breakdown protection designed in this regulator may require the removal of the input voltage to re-start the regulator.

Regulator Performance Specifications

Input voltage test condions are as follows: $V_1 = V_o + 3 \text{ Volts}$, $V_2 = V_o + 10 \text{ Volts}$, $V_3 = V_o + 150 \text{ volts}$, or the maximum input whichever is less.

TEST CONDITIONS

PARAMETER	SYMBOL	V_{IN}	I_o	T_J	MIN	MAX	UNITS
Input Voltage	V_{IN}		10MA.		$V_o+2.6$	25(5)	.Volts
Output Voltage	V_o	V_1 to V_2	10MA to 8.0 Amp	25°C	$0.95[V_o]$ (1)	$1.05[V_o]$.Volts
Input-Output Differential	$V_{IN}-V_o$		8.0 Amp	0°C to $+125^\circ\text{C}$	2.6		.Volts
Output Current	I_o	V_1	0.5 Amp	0°C to $+125^\circ\text{C}$		20.	.Volts
Line Regulation (2)	$\text{REG}(\text{LINE})$	V_1 to V_3	5A	25°C	0	8.0	.Amps
Load Regulation (2)	$\text{REG}(\text{LOAD})$	V_1	10MA to 8.0 Amp	25°C		2.0	$\%V_o$
Quiescent Current	I_Q	V_1	Output/Open	25°C		0.6	$\%V_o$
Quiescent Current Line	$I_Q(\text{LINE})$	V_1 to V_2	10MA.	25°C		20.	.MA
Quiescent Current Load	$I_Q(\text{LOAD})$	V_1	10MA to 8.0 Amp	25°C		5.	.MA
Current Limit	I_{LIM}	V_o+5V		25°C		14.	.Amps
Short Circuit Current	I_S	V_o+5V		25°C		14.	.Amps
Temperature Coefficient	T_C	V_1	0.1 Amp	0°C to $+125^\circ\text{C}$		0.03	$\%V_o/^\circ\text{C}$
Output Noise Voltage	V_N	V_1	0.1 Amp	0°C to $+125^\circ\text{C}$		10(3)	$\mu\text{Vrms}/V$
Ripple Attenuation	RA	V_1	2.0 Amp	0°C to $+125^\circ\text{C}$	60(4)		.dB

- (1) Nominal output voltages are specified under ordering information.
- (2) Instantaneous regulation, average chip temperature changes must be accounted for separately.
- (3) $BW=10\text{Hz} - 100 \text{ Hz}$.

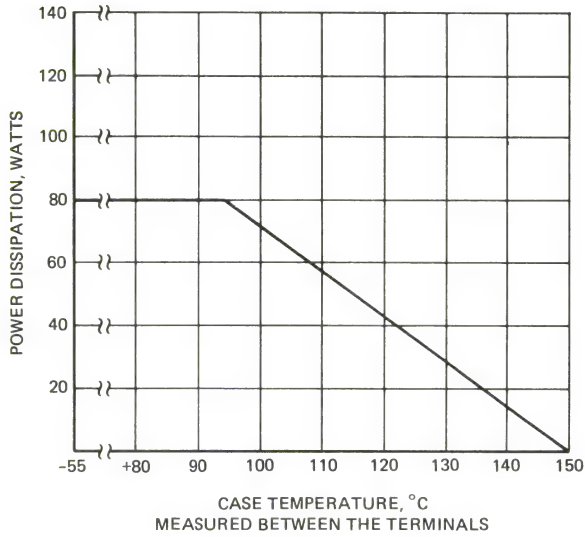
- (4) Ripple attenuation is specified for a 1 VRMS, 120 Hz input ripple. Ripple attenuation is a minimum of 60 dB at a 5 volt output.
- (5) The maximum input voltage of the LAS-3900 series is limited by maximum input-output differential voltage, maximum power dissipation, or the current limit-SOA, whichever is less.

Price List

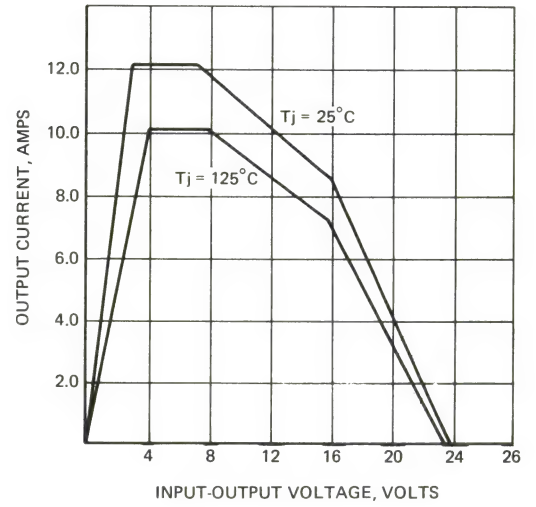
NOMINAL V_o VOLTS	DEVICE PART NO.	QTY 1-24	QTY 25-49	QTY 50-99	QTY 100-249	QTY 250-499	QTY 500-999	QTY 1000-2499	QTY 2500-4999
5	LAS-3905	\$18.00	\$16.50	\$15.75	\$14.75	\$13.00	\$11.90	\$10.65	\$10.00

CONTACT THE FACTORY FOR HIGHER QUANTITY PRICES. DEVICE CONFIGURATIONS, SPECIFICATIONS, AND PRICES SUBJECT TO CHANGE WITHOUT NOTICE

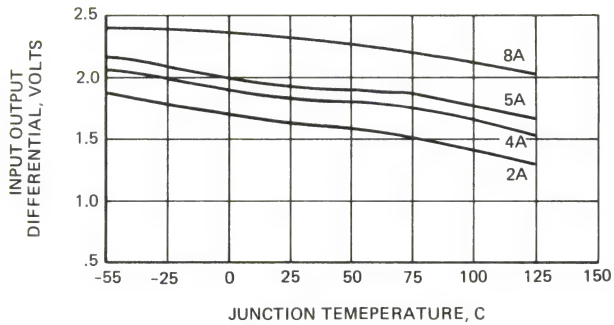
Operational Data



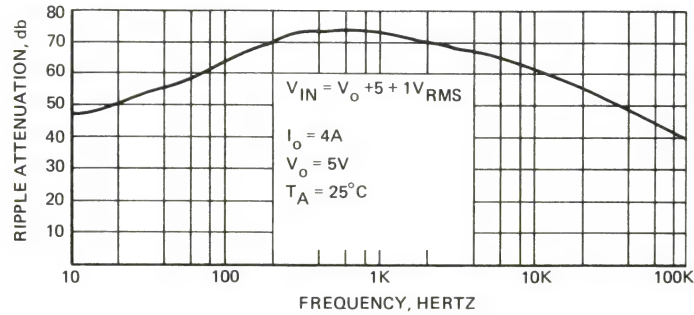
POWER DERATING



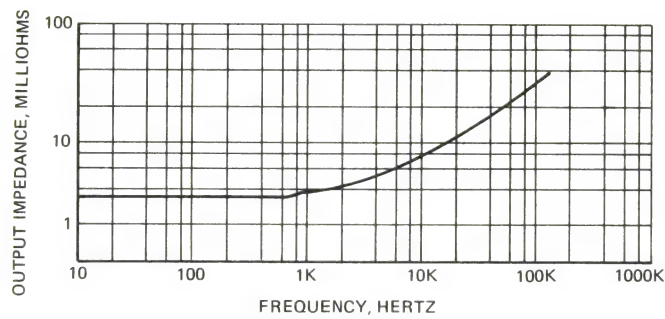
TYPICAL CURRENT LIMIT
VS INPUT OUTPUT
VOLTAGE DIFFERENTIAL



TYPICAL INPUT-OUTPUT
DIFFERENTIAL VOLTAGE vs
JUNCTION TEMPERATURE

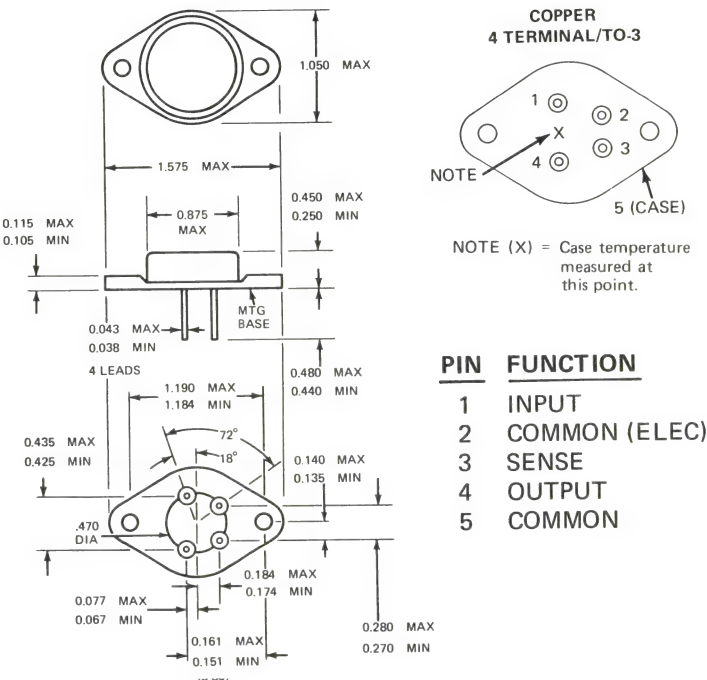


TYPICAL RIPPLE ATTENUATION
vs FREQUENCY

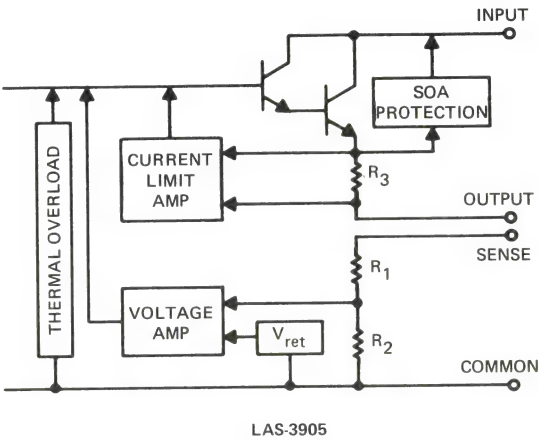


TYPICAL OUTPUT IMPEDANCE
vs FREQUENCY

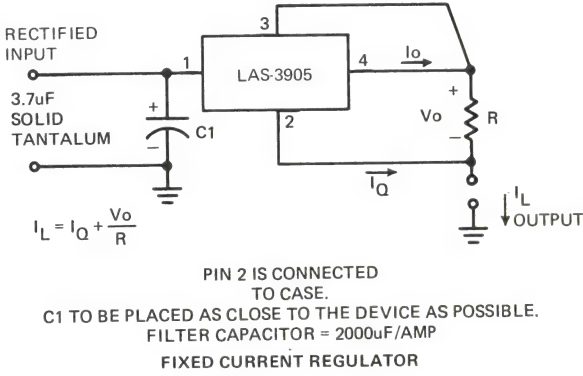
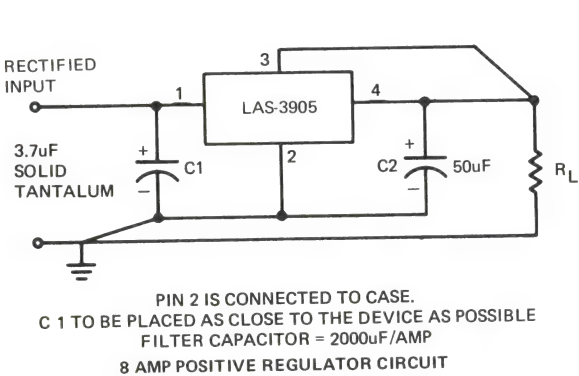
Outline Drawing



Functional Block Diagram



Typical Applications



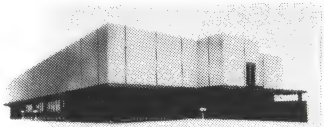
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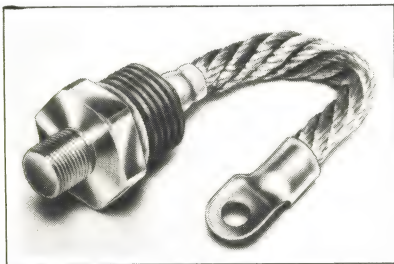
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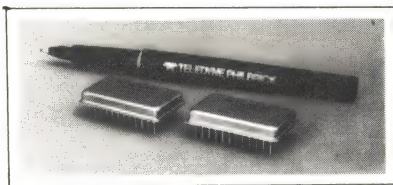
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New Products



HIGH-POWER RECTIFIER. Capable of withstanding a single-cycle surge current of 9000A, Model SKN-40 also passes an average forward current of 400A (900A max). The unit features a reverse voltage in the 1800 to 3000V range and a V_f of 1.45V max. Each part comes with a ribbed isolator, which allows fault-free operation in high-pollution atmospheres. Junction-to-case thermal resistance equals 0.11 °C/W. **Semikron International Inc.**, Box 83, Hudson, NH 03051. Phone (603) 883-8102. **Circle No 231**

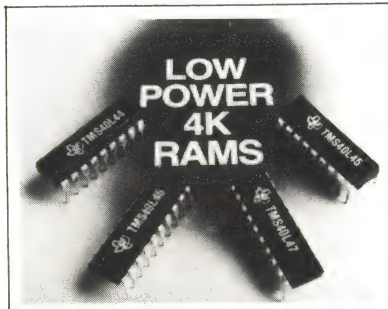
SEVEN-SEGMENT DRIVER. Pin compatible with 7447, 9374 and 8674 drivers, the NE 586 common-anode LED decoder/driver features 25-mA constant-current outputs; LOW-loading, bus-compatible, latched BCD inputs; and ripple blanking on leading/trailing zeros. You can specify alternative fonts because ROM implements the segment decoding. The chip requires a 4.75 to 5.25V (7V max) supply, but its inputs withstand 15V. \$1.78 (100). **Signetics**, Box 9052, Sunnyvale, CA 94086. Phone (408) 739-7700. **Circle No 232**



HI-REL V/F CONVERTERS. Processed to MIL-STD-883, Models 4731 (10 kHz) and 4733 (100 kHz) have a full-scale nonlinearity of less than $\pm 0.005\%$ over the -25 to $+125^\circ\text{C}$ range. These hybrid units handle positive, negative and differential input signals, using ± 9 to $\pm 18\text{V}$ supplies. Guaranteed specs include TC of ± 50 ppm/°C, V_{OS} TC of ± 100 $\mu\text{V}/^\circ\text{C}$ and 100-dB dynamic range. A current input resolves levels as low as 1 nA, making possible operation with full-scale V_{in} s of <250 mV to $>100\text{V}$.

For more information, Circle No 95

4731, \$125; 4733, \$135. **Teledyne Philbrick**, Allied Dr at Rte 128, Dedham, MA 02026. Phone (617) 329-1600. **Circle No 233**



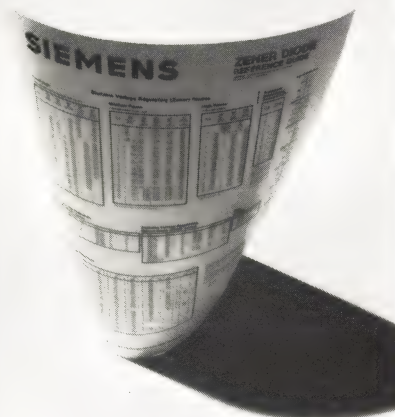
LOW-POWER RAMS. Models TMS40L44 and TMS40L46 ($4\text{k} \times 1$) and TMS40L45 and TMS40L47 ($1\text{k} \times 4$) come in three speed ranges—450-, 250- and 200-nsec maximum access times. Fully static units, they operate from single +5V supplies and are TTL compatible. Typical power dissipations for the 200-nsec 40L44 and 40L45 units are 200 and 250 mW, respectively. The 40L46 and 40L47 units have a power-down feature providing 6-mW typical dissipation. The 40L44 and 40L45 units come in 18-pin DIPs, the others in 20-pin packages. 200-nsec units, \$11.40 (100); 450-nsec units, \$6.90. **Texas Instruments Inc.**, Box 1443, MS 669, Houston, TX 77001. Phone (713) 494-5115. **Circle No 234**

TEMPERATURE CONTROLLER. Accepting inputs directly from a thermistor, the AY-3-1270 measures temperatures arising in domestic and commercial equipment and displays them on either LED or LCD panels. Its 40-pin DIP includes a power-failure detector and warning indicator for out-of-range conditions. Two control outputs can be used for external alarm circuitry or compressor control. One output operates at the temperature setpoint plus hysteresis (0, 0.2, 0.4, 0.8, 2, 4 or 8°C), the other at setpoint minus hysteresis. Accuracy of temperature sensing is $\pm 1^\circ\text{C}$, while the temperature range depends on the thermistor chosen. The chip requires one supply voltage between 7.2 and 10.8V. \$8 (100). **General Instrument Corp.**, 600 W John St, Hicksville, NY 11802. Phone (516) 733-3606. **Circle No 235**

SIEMENS

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For more information, Circle No 96

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tically held within peak to peak amplitude of the signal. If there's no signal a zero line is displayed. Triggering is instant and unambiguous for a wide variety of measurement conditions. For phase measurements the level can still be adjusted between the extremes of the signal amplitude. TV trigger is also fully automatic.

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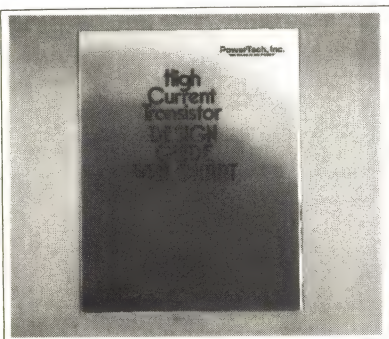
*U.S. Domestic Price Only.



Test & Measuring
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Literature



Power-transistor wall chart

This design-guide chart unfolds to colorfully illustrate the performance of 53 of the company's high-current power transistors. The chart depicts power-transistor and module anatomy, along with package options. It also provides specs and a list of applications. **PowerTech Inc.**, 0-02 Fair Lawn Ave, Fair Lawn, NJ 07410.

Circle No 236

New products highlight data-comm catalog

This latest "Black Box" edition features descriptions of the company's data communication devices including test sets, switches, interfaces, converters, stunt boxes, modems and modem eliminators, as well as cables and connectors. Along with coverage of 25 new products, the catalog presents specs, features, applications and prices of each device listed. **Expandor Inc.**, 400 Sainte Claire Plaza, Upper Saint Clair, PA 15241.

Circle No 237

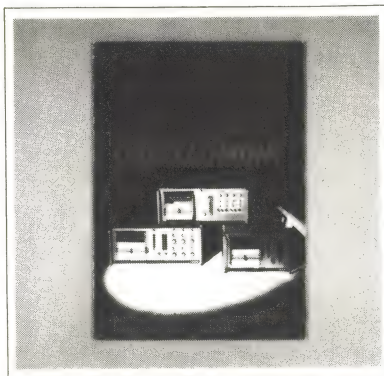


Winchester-disc-drive technology primer

"Who's Selling Rifles to the Indians?" explains the evolution of the Winchester disc drive and covers the

differences between that technology and earlier innovations. A brief history traces development from IBM's RAMAC 305, with its 50 discs and 5M-byte capacity to today's single-disc Winchester drives having as much as 33M bytes of data storage. The pamphlet describes both track-and bit-density gains and improvements to disc-drive reliability. **Priam Corp.**, 20730 Valley Green Dr, Cupertino, CA 95014.

Circle No 238



Liquid-jet oscillographs: Principles, applications

Through diagrams, photos and text, this 24-pg booklet explains the liquid-ink-jet printing principle used in the company's line of portable and benchtop oscillographs. Comprehensive specs for instruments employed in industrial maintenance and monitoring applications complete the brochure. **Siemens Corp.**, Measuring & Scientific Instruments Div, 2 Pin Oak Lane, Cherry Hill, NJ 08034.

Circle No 239

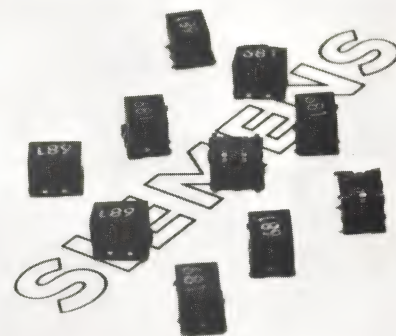
Note describes resistor pulse-handling capabilities

"Pulse Handling Capability of Wirewound Resistors," a 24-pg application booklet, explains how to pick the right wirewound resistor to withstand short-duration pulses. For pulses from 0.5 to 5 sec long, the pamphlet explains how to calculate the maximum energy that can be safely applied to the resistor. For pulses lasting less than 0.5 sec, the brochure offers a series of charts to help you determine if the calculated pulse energy is greater or less than a given resistor's rated energy. **TRW/IRC Resistors**, Box 1860, Boone, NC 28607.

Circle No 240

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For further information on Siemens full line of Ferrites that offer a wide range of applications, write:

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For more information, Circle No 98

Literature



A potpourri of offerings for kit builders

The 96-pg Winter 1979 Heathkit catalog describes a variety of electronic kits in such areas as color TV, hi-fi components, amateur radio, test instruments, personal computers and weather instruments. New products in this issue include a dc to 35-MHz dual-trace, delayed-sweep scope; a rack-mounted AM/FM stereo tuner;

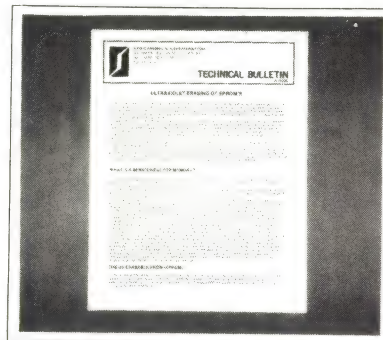
and a solid-state heat/cool setback unit for home energy saving. **Heath Co**, Benton Harbor, MI 49022.

Circle No 241

Extend storage capability with digital scopes

Bulletin 449-5 illustrates the advantages of digital-storage oscilloscopes compared with storage-tube models. The 6-pg publication presents specs on two of the company's portable dual-trace units, which are designed for flicker- and fade-free viewing of both long-term events and transients. **Gould Inc**, Instruments Div, 3631 Perkins Ave, Cleveland, OH 44114.

Circle No 242



EPROM bulletin shows erase times

Spectronics Corp's "Ultraviolet Erasing of EPROMs" (A-78286) offers an in-depth discussion of erase times and contains tables listing the nominal erasing energy required for various popular EPROM types. A pair of charts show the erasing times required for simultaneous erasure of several EPROMs using the company's UV sources. Also described are the advantages of EPROMs and how they work. **Adco Electronics**, 2182 DuPont, Suite 222, Irvine, CA 92715.

Circle No 243

Learn what's new in electrical contacts

In addition to describing the company's electrical contacts, this 21-pg brochure lists properties of powder-metal contact materials, copper-base contact-support materials and the silver-braze alloys used for attaching contact tips to contact supports. Publication P102 also relates the particle sizes of tungsten and



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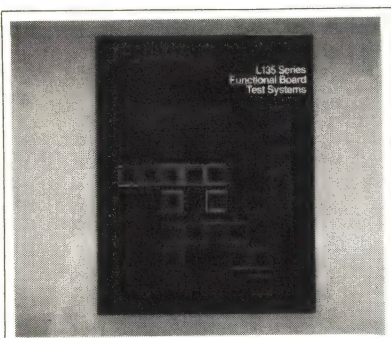
7205

For more information, Circle No 101

Literature

tungsten-carbide powders to the wear characteristics of silver-tungsten and silver-tungsten carbide contacts. The brochure provides weight-system conversion factors (troy, avoirdupois and metric), a table of crown heights for given contact diameters and face radii, application factors and an explanation of how order prices are adjusted to the market price of silver. **Advanced Metallurgy Inc.**, 1011 E Smithfield St, McKeesport, PA 15135.

Circle No 244



System expands into a series of board testers

A 4-pg brochure illustrates the L135 functional board-test systems, which serve a variety of production-line testing needs. The folder details the family's modular system architecture that permits users to move up to larger configurations and increase the number of testing modes with virtually no production-schedule disruptions. **Teradyne Inc.**, 183 Essex St, Boston, MA 02111.

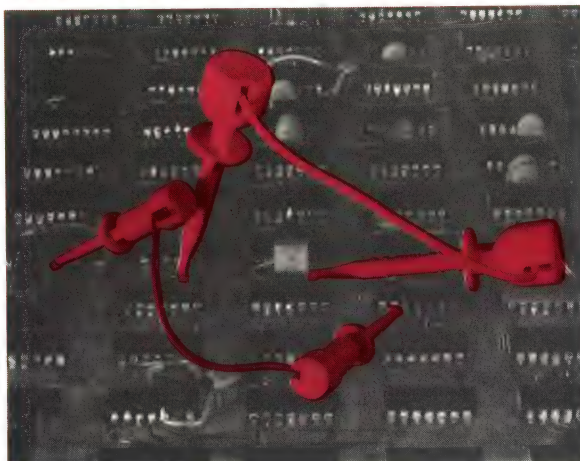
Circle No 245

You can specify and order with instrumentation note

Catalog I highlights a line of instrumentation for the measurement, analysis and/or recording of power-line disturbances and power-system parameters. Other general-purpose instruments measure phase/gain, impedance, current voltage, Q and time/frequency. The brochure also describes the company's SERs (Sequence-of-Event recorders). Each product section lists features, supplies comprehensive details of the instruments and plug-ins, and, where applicable, performance curves. The last page lists company technical literature available upon request.

Dragnet Engineering Laboratories Inc., 2385 S Clinton Ave, South Plainfield, NJ 07080. Circle No 246

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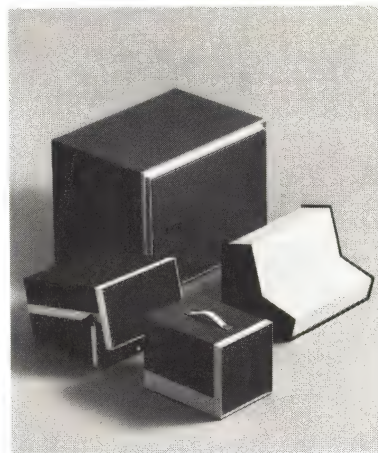
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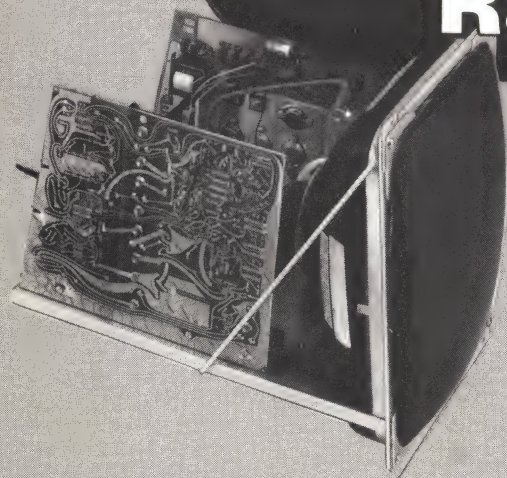
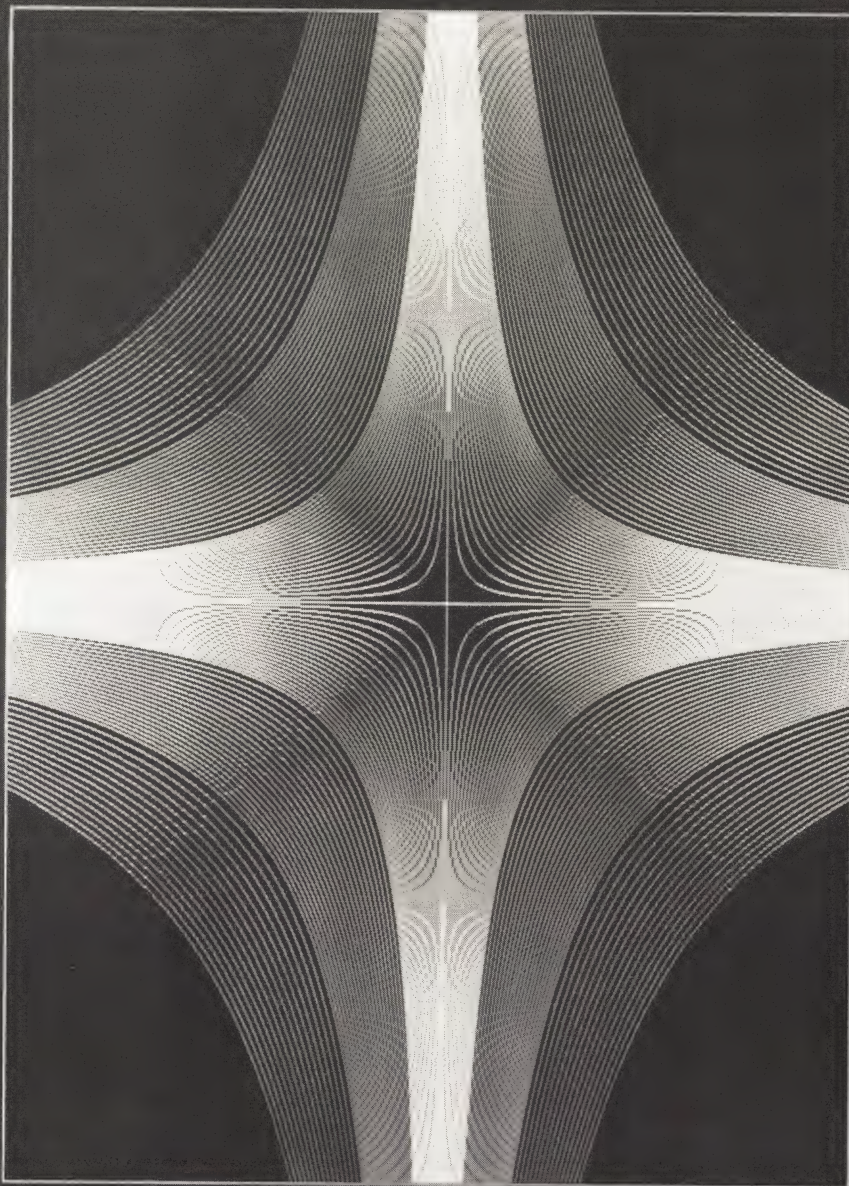


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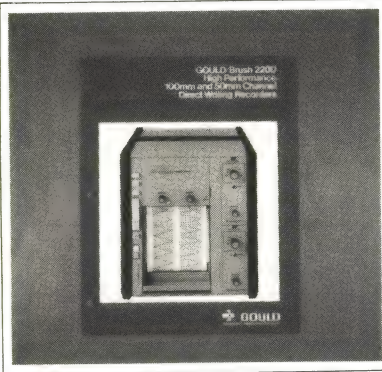
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Literature



One- and 2-channel high-performance recorders

A photo in this 6-pg bulletin points out the major features of the 2200 Series of direct-writing recorders, and an actual chart sample depicts the recorders' resolution and trace fidelity. The brochure also supplies complete specs and options for the series. **Gould Inc.**, Instruments Div, 3631 Perkins Ave, Cleveland, OH 44114. **Circle No 247**

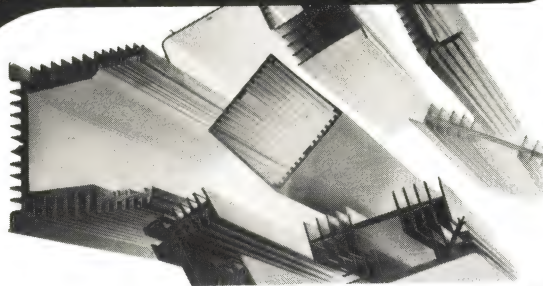
Low-pass filter offers 230 dB per octave

Providing information on the Model 752 programmable, dual low-pass anti-aliasing filter, this 4-pg data sheet describes the device as the closest approach to the ideal "brickwall" filter allowable by the present state of the art. Listed features include a rolloff rate, in each of two identical channels, of better than 115 db/octave (cascading permits 230 db/octave)—illustrated by three CRT traces. The brochure briefly describes such typical applications as band-limiting of analog signals before A/D conversion; signal conditioning; waveform analysis; noise studies; distortion measurement and data recording and playback. **Rockland Systems Corp.**, Rockleigh Industrial Park, Rockleigh, NJ 07647. **Circle No 248**

Varied applications for telemetry products

Twenty data sheets constitute this package, which details a complete line of receivers, transmitters, amplifiers, multiplexers and synthesizers. Each sheet begins with a short description of a product and its typical applications, then lists complete specs. **Communitronics Ltd.**, 1324 Motor Parkway, Hauppauge, NY 11787. **Circle No 249**

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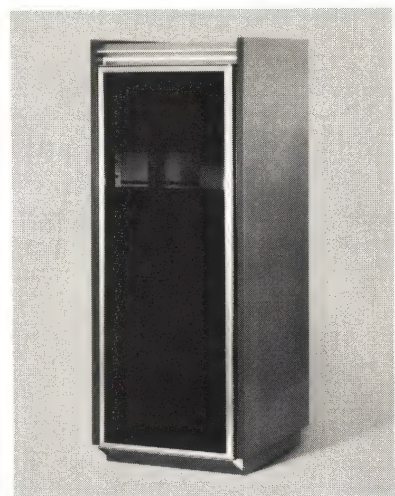
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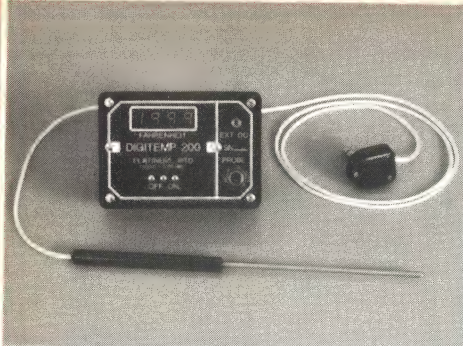
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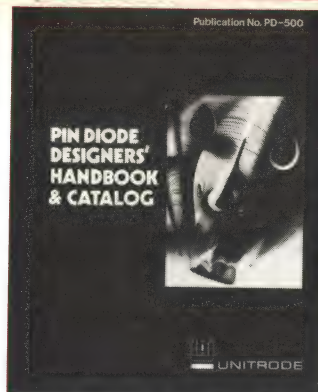
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For more information, Circle No 105



DIGITEMP 200 PLATINUM RTD DIGITAL THERMOMETER spans -328°F to $+1562^{\circ}\text{F}$ with 0.2% accuracy and 1°F resolution. Also available is the **DIGITEMP 100** digital meter which uses a Semiconductor Type sensor and spans -55°C to $+150^{\circ}\text{C}$ with 0.5°C accuracy and 0.1°C resolution. A variety of probes are available for either meter, and both may be ordered in either Fahrenheit or Centigrade. Prices start at \$155. **MID-CONTINENT COMMUNICATIONS CORP.**, 3618A Noland Court, Independence, Mo. 64055. (816) 461-1334.

For more information, Circle No 106



PIN Diode Handbook and Catalog For RF Engineers

Complete catalog of Unitrode's PIN Diode data. Including selection guide relating PIN Diode types to applications such as: common RF switches, attenuators, transmit-receive switches, and phase shifters. Bias, thermal conditions, and distortion are discussed. For your copy: contact Unitrode Corporation, 580 Pleasant St., Watertown, MA 02172, (617) 926-0404.

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Literature

Handbook explains workings of mag-tape recorders

"Modern Instrumentation Tape Recording" discusses: the physics of magnetic-tape recording; media, means and mechanisms for recording and reproduction; direct, FM and digital recording of analog signals; tape-movement systems; tape and tape heads; and selection and specification of instrumentation tape recorders. The last chapter of the 140-pg opus highlights comprehensive applications. \$6. **EMI Technology Inc.**, 100 Research Dr, Stamford, CT 06906.

INQUIRE DIRECT

Catalog chock full of test accessories

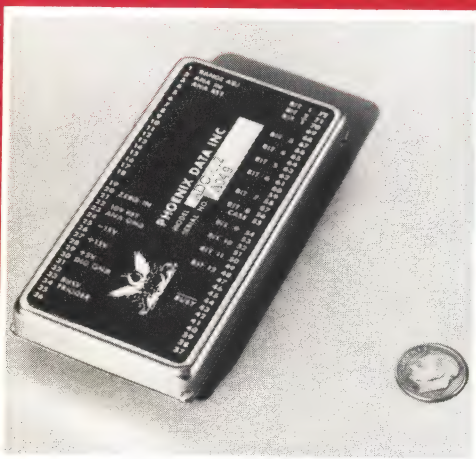
New product descriptions combine with details of previously offered electronic-test-accessory families in this 100-pg document. Accessories described include molded patch cords, cable assemblies, test-socket adapters, molded test leads, plugs, connecting cords, probes and holders. Photographs and drawings accompany ordering information, BNC- and triaxial-cable assembly procedures and two tables for metric and temperature conversions. **ITT Pomona Electronics**, 1500 E Ninth St, Pomona, CA 91766.

Circle No 250

A power supply for every need

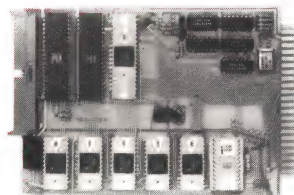
Containing 32 pages of helpful application hints and a design tutorial, this 144-pg catalog also describes the company's power supply line. The booklet groups the products by shared characteristics: modular/linear, modular/ferroresonant, modular/switching, laboratory/systems, high speed/unipolar, high speed/bipolar, and programmer and interfaces. It lists accessories and hardware, and also offers a glossary of power-supply terms. **Kepeco Inc.**, 131-38 Sanford Ave, Flushing, NY 11352.

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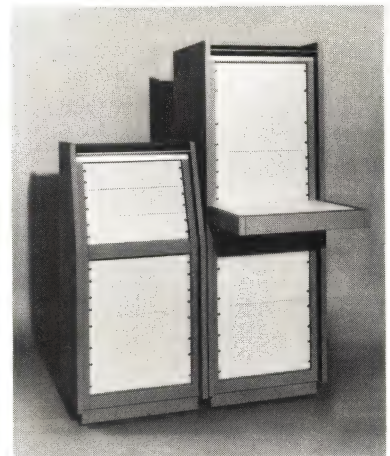
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
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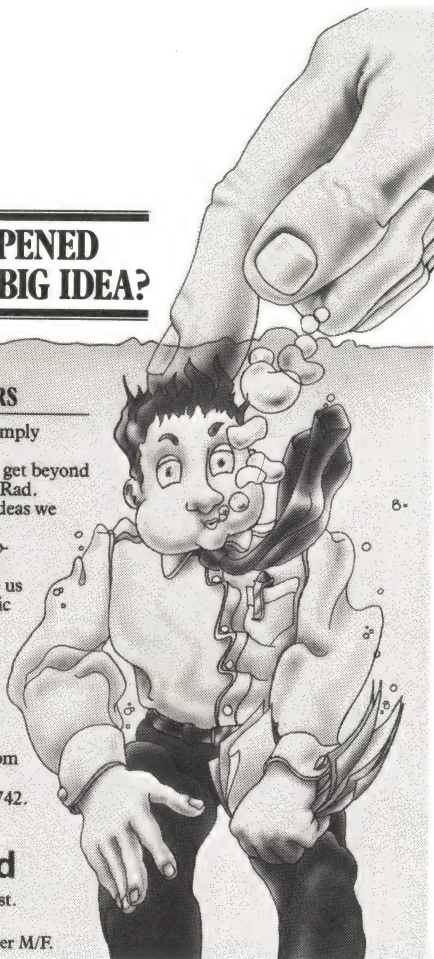
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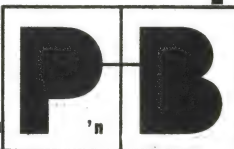
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Crossed signals

Dear Editor:

As a busy EE, although I find EDN invaluable, I do not have the time to read it all the way through. Therefore, it would be a great service to your readers if you would supply them with special glasses that would make the essential points stand out in red, the medium-interest passages appear yellow and the non-essential lines disappear altogether.

Sincerely,
J R Vague
JRV Associates
Blue Forks, MI

Organic memory is a slice of life

HAL Corp has announced that scientists at its de'Hormel research facility in Paramus, NJ, have succeeded in storing up to 40 bytes of unformatted data on a single 5-1/4-in. slice of bologna. Dubbed a "really-floppy disc" by its developer, Dr Otto Oikenheimer, the pork platter attains its outrageous storage capacity by whirling around and around and around at 33-1/3 rpm until little grease specs fly off. Each spec represents one bit of digital data.

The port sports a 4-port EIE I/O bus on rye. Mustard is optional; kosher versions will soon be announced.—**BP**

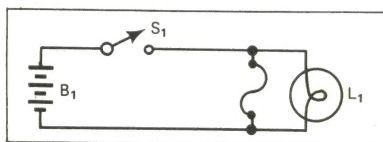
TWD International's part premiers

In a bold move sure to send shock waves through the electronics industry, TWD International has an-

nounced its fourth significant revolutionary breakthrough of the year—the Termodigitrator (Mark I).

Industry sources say the new component is bigger than a breadbox, faster than a speeding bullet, the key to peace in our time and the potential savior of all life as we know it on earth.

TWD International (formerly Teeny Weeny Devices Inc) is a 7-yr-old firm specializing in the manufacture of high-noise op amps, lenient voltage regulators and 10%-tolerance timer chips.—**JB**



Fuse tester for all seasons

Need a simple, portable fuse tester that doesn't require extensive operator training? The one shown provides a complete test—if the light comes on, the fuse is bad. The circuit suits all types of fuses, both metric and English; color-coded units work with it, too.—**ET**

To Vote For This Design

Circle No 6-7/8

Check out this disposable μ P

Model 80808080 sports many features that make it suitable for no applications whatsoever. Fabricated with ECSST (English-Channel silicone semiconscious technology) water gates, the device implements systems which would have cost \$40G, filled Grand Central Station

and consumed all the power it took to run North America just 20 yrs ago. To permit the ruggedized, glass-passivated chip to handle power in the kilowatt region, a RIP (rarely in-line package) contains space for seven standard MIL-TFD-41S ice cubes. For specialized applications, an output-fuss-free RIP leadless package permits greater packing density (Model 80808080 RIP-OFF). Chip versions are also available. Price: High. Delivery: How long can you tread water? National Texsil Interolachild Hemiconductor Inc, 2¹⁶⁻¹ E Rte 2⁸⁻¹, Revlon-on-Avon, Taxachusetts 31415.—**DR**

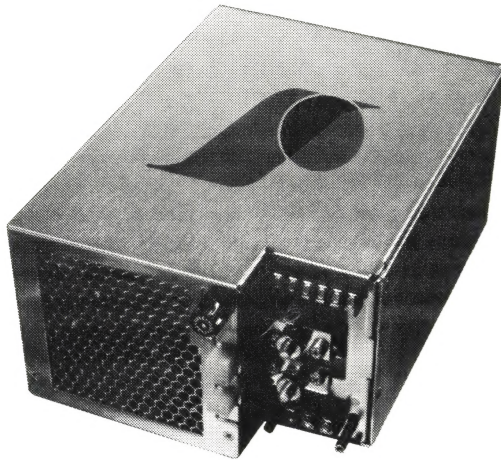
Circle No π

When you hate to remember

This versatile, super-volatile Model 20/140 random-access forgetter (RAF) enables you to forget the things you wish you never knew (and goes OFF even when the lights stay ON). The names of friends you wish you never had, the time of appointments you never wanted to keep and the sum of the tax bill you never intended to run up, once entered into this device, disappear forever. With an infinite access time and infinite capacity, the unit comes in special expanded-capability Presidential (-PFIB), Senatorial (-SFIB) and Special Advisor (-SAFIB) Models for testimony before congressional committees. **Anacreon Memory Co**, 1023 Morpheus St, Last Chance, SN.—**JV**

Circle No 3.3333

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A.C. Input: 92 to 138 or 184 to 250V single phase 47 to 63 Hz.

D.C. Input: 24, 48, 120 or 240 VDC standard.

Brownoutproof: Supplies ignore most line variations and continue to supply specified regulated outputs at full load if input voltage drops as low as 80 or 140 VAC.

Total Error Band: Output deviations will not exceed $\pm 2\%$ due to line changes, static and dynamic load changes, ripple and noise spikes, temperature variations and drift.

Power Loss Holdup: Output will remain within regulation 30 msec after loss of AC input at full load and nominal line.

Safety Standards: Standard models are recognized to UL478.

SINGLE OUTPUT SUPPLIES

AC INPUT MODEL DC INPUT MODEL		PM2496A PM2721	PM2497A PM2722	PM2498B ---	PM2499 ---
OUTPUT VOLTAGE	TYPE NUMBERS (Add Amps in Blanks)		OUTPUT CURRENT	OUTPUT CURRENT	OUTPUT CURRENT
	AC MODELS	DC MODELS	CURRENT	CURRENT	CURRENT
2	20	2F	100	200	400
3	30	3F	60	100	200
5	50	5F	50	100	200
5	50	5F	60	120	---
5	50	5F	---	150	300
12	120	12F	25	60	120
15	150	15F	25	50	100
18	180	18F	22	45	90
21	210	21F	18	36	72
24	240	24F	16	33	66
28	280	28F	13	27	54
48	480	48F	8	16	32
SIZE (INCHES) (CENTIMETERS)		5x8x11 12.7x20.3x27.9	5x8x11 12.7x20.3x27.9	5x18x11 12.7x40.6x27.9	5x8x15 12.7x20.3x38.1
WEIGHT (POUNDS) (KILOGRAMS)		16 7.3	18 8.2	35 15.9	25 11.4

MULTIPLE OUTPUT SUPPLIES

AC INPUT MODEL DC INPUT MODEL		PM2675A PM2775	PM2676A PM2776	PM2677A	PM2678A			
MAX. TOTAL OUTPUT POWER IN WATTS		375W	600W	750W	850W			
MAIN CHANNEL	OUTPUT VOLTAGES AVAILABLE	2, 3, 5, 12, 15, 18, 21, 24, 28, 48						
	MAX. POWER IN WATTS	250W	500W	600W	750W			
SECOND CHANNEL	OUTPUT VOLTAGE	5	12	15	18	21	24	28
	OUTPUT CURRENT MAX. (see note 1)	7	7	7	CHECK FACTORY			
THIRD CHANNEL	OUTPUT VOLTAGE	5	12	15	18	21	24	28
	OUTPUT CURRENT MAX. (see note 1)	10	10	10	CHECK FACTORY			
FOURTH CHANNEL	OUTPUT VOLTAGE	5	12	15	18	21	24	28
	OUTPUT CURRENT MAX.	4	4	4	4	3	3	
SIZE (INCHES) (CENTIMETERS)		5 x 8 x 11 12.7 x 20.3 x 27.9 (see note 2)						
WEIGHT (POUNDS) (KILOGRAMS)		26 9						

Note 1: Higher currents available to 30 Amperes.

Note 2: Add 1 9/16" (4 cm.) for external fan on Models PM2677A, PM2678A.

For more information, Circle No 111

The Pioneers in Switching Supplies



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